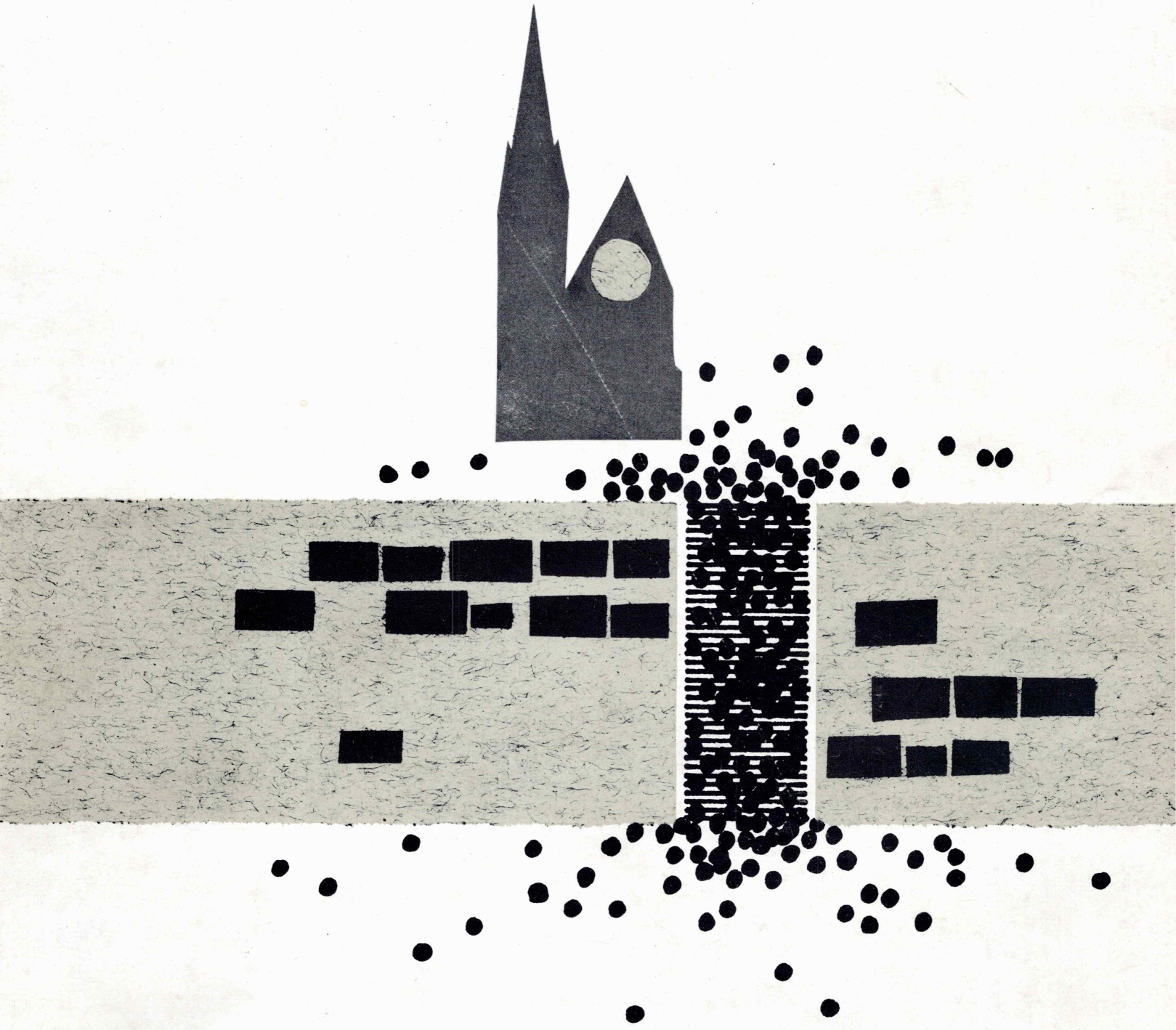
Traffic in a New Zealand City



Traffic In A New Zealand City

edited by W. B. JOHNSTON

Reader in Geography

University of Canterbury

This publication is a study of Christchurch, a city of a quarter-million people and the major urban centre in the South Island of New Zealand. *Traffic in a New Zealand City* is based on studies undertaken by the Christchurch Regional Planning Authority for the preparation of a master transportation plan. The studies have been collated and presented by R. G. Golledge, W. B. Johnston, L. J. King and A. Williman of the University of Canterbury in collaboration with the Christchurch Regional Planning Authority.

Many urban problems are already apparent in New Zealand's cities which are essentially those of the Twentieth Century. Although European settlement is only 150 years old, the cities are much younger still. At the beginning of the Twentieth Century, there were only four cities of over 20,000 population and none had more than 70,000 persons. At that time their total population was less than 30 per cent of New Zealand's 800,000 people. Now, some sixty years later, 60 per cent of the population of two and a half millions is urban. Two out of every five New Zealanders live in cities of over 100,000 population.

(*continued on back flap*)

Dust jacket designed by Mark Cleverley

CHRISTCHURCH
REGIONAL PLANNING AUTHORITY

Traffic In A New Zealand City

Traffic In A New Zealand City

$15.00

Traffic
in a
New Zealand City

V. C Browne Airview

THE CITY OF CHRISTCHURCH

Traffic In A New Zealand City

EDITED BY

W. B. JOHNSTON

READER IN GEOGRAPHY

UNIVERSITY OF CANTERBURY

CHRISTCHURCH REGIONAL PLANNING AUTHORITY

CHRISTCHURCH NEW ZEALAND

1965

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R. G. Golledge, W. B. Johnston, L. J. King and A. Williman
of the University of Canterbury

in collaboration with

the Christchurch Regional Planning Authority

and under the general editorship of

W. B. Johnston

Foreword

In December 1850 the first settlers of the Canterbury Association arrived to pitch their tents beside the swamp lands of the estuary and to begin the task of building the town that is now Christchurch. It must have been a daunting prospect but they set about it with enterprise, and with high hope for the future. Today the prospect of the problems that the motor car has brought is no less daunting and stands out in strange contrast to the empty wastelands of a hundred years ago.

There is little doubt that the flood of motor cars will continue to increase and that, come what may, it will change our city and our way of life. We have a choice to make. We may evade the issues and, by giving superficial treatment of the traffic symptoms that annoy us, allow the flood to overwhelm us. Or we may grasp the opportunity it offers to take the large-scale measures needed to re-create the city, for our own time and our children's. To do so will require, in full measure, the qualities of mind and spirit that imbued our forefathers when they caught the vision of a city of the plains.

The problem is much more than just one of keeping traffic moving. We appreciated from the start that the solution to the traffic problem must be closely integrated with development and redevelopment possibilities for the city as a whole. It was for this reason that the Christchurch Regional Planning Authority was given the responsibility of preparing a transportation plan for Christchurch. It was for this reason also that it was decided to embark on a full-scale investigation that would attempt to explain and resolve traffic growth and requirements in terms of the future pattern and growth of urban activities.

The work fell into two main phases. First that of establishing the necessary design data as a basis on which to evaluate the problems and prepare the plan. Second that of devising a solution to meet the problems that were disclosed.

This book deals only with the first phase. It covers the studies of urban activities and the trips they generate, the processes used, projections, and a first discussion of problems. Additional considerations concerned more with detailed layout and design, especially of the city centre, were considered in the second phase when the many and various solutions were being devised and tested. These considerations are beyond the scope of this publication, though the plan for the final solution, which took the form of a major network of roads, together with an estimate of parking facilities, their type and general distribution in the city centre, was presented to the public of Christchurch in 1962 for their examination and comment. At the same time the plan was presented to the various local authorities and government agencies concerned and has since been approved by them all, subject to some reservations by the Christchurch City Council and the Paparua County Council.

The officers of the Authority, augmented by a senior engineer of the Ministry of Works, were responsible for the design and organisation of the work. But a task of this magnitude required additional help and it could not have been carried through without the willing cooperation of a great many people. Those who rendered valuable assistance are recorded in Appendix A. They include the constituent authorities of the Regional Planning Authority and other organisations, together with Government Departments, and in particular the Ministry of Works and the Applied Mathematics Division of the Department of Scientific and Industrial Research. The Authority is particularly indebted to Dr. B. I. Hayman for the work he undertook in connection with the mathematical and statistical analysis of the data.

This book is published for two main reasons. First because it is important that the basis of the Christchurch Master Transportation Plan should be as widely known as possible amongst Christchurch citizens. Second to record, in a convenient and permanent form, the processes involved and the information obtained. The Christchurch studies were the first of their kind to be made of a New Zealand city. It is hoped that this record of the investigations will be of interest and value not only to Christchurch people but to others, whether in New Zealand or overseas, who may be facing similar problems or working in related fields.

The problem, when publication was first considered, was how it could be done, for the small staff of the Authority was too heavily committed with current work. Then came the collaboration with Mr. W. B. Johnston, M.A., a Reader in Geography at the University of Canterbury. He not only enlisted the help of three other members of the staff of the University but took over the work of General Editor. Between them they have sifted and collated the great mass of published and unpublished material in the offices of the Authority. It has been a laborious task and the Authority is most grateful to the four authors for the great amount of work they have done. The value of their work is reflected in this book which the Authority is pleased to publish.

E. J. BRADSHAW, *Chairman,*
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§ Served as Chairman for a period in 1959 during the absence overseas of Mr. E. Somers.
* These members and officers served for part only of the time during which the studies were undertaken.
† Now deceased.

Table of Contents

APPENDICES

Plates

Tables

Figures

Introduction

Cities are of ancient origin. The transformation of agricultural villages into the first cities lies back in prehistory when craftsmen, merchants, priests, clerks and officials, sustained by surplus food brought in from the surrounding countryside, began their urban occupations. This great revolution appears to have occurred about 4,000 B.C., first in Mesopotamia, soon to spread to Egypt and later elsewhere. During succeeding millennia urban living was the common way of life for very few people however.

The forces released in the Nineteenth Century by the industrial, agricultural and transport revolutions encouraged rapid population growth and, at the same time, promoted the growth of great urban concentrations with high densities of housing within small areas. These Nineteenth Century cities were compact, concentrated and crowded because power could not be transmitted over long distances and most workers had to walk to their factories. Since 1800 the urban element, as a percentage of the world population, has doubled every 50 years. Whereas in 1800 only one in every 40 persons lived in cities of over 20,000 population, in 1950 one in every five persons was a citizen.

The latest and present phase of urban expansion is a product of a technological revolution in transport with the development of the internal combustion engine and the dynamo. Cars, buses and electricity have permitted the spread of cities, decrease in housing densities, and greater separation of living and working places. Urban man in the mid-Twentieth Century is a nomad. He spends a working day in office or factory only to abandon it in his daily migration home. At the weekend he pastures on open spaces about the city or in rural areas and, in turn, abandons them in his journey home. And then in his seasonal migration he moves far and wide in search of an annual holiday place, be it another city, or beach, boat, bach or bush. The permanent interest of this urban nomad is often only in his home and his migrations may bring few benefits to his temporary resting places.

The processes of urban change are being accentuated by the increasing number of people living in cities which is at a rate significantly faster than that for the growth of world population as a whole. This urban growth threatens to outpace our ability to understand and guide it.

Many urban problems are already apparent in New Zealand's cities which are essentially those of the Twentieth Century. Although European settlement is only 150 years old, our cities are much younger still. At the beginning of this century, there were only four cities of over 20,000 population and none had more than 70,000 persons. At that time, their total population was less than 30 per cent of New Zealand's 800,000 people. Now, some sixty years later, 60 per cent of the population of two and a half millions is urban and two out of every five New Zealanders live in cities of over 100,000 population.

The urban population of New Zealand is increasing at an accelerating rate with every indication of continued growth in the foreseeable future. Urban living directly affects, and should be the concern of the great majority of the country's people but New Zealand is in many ways only beginning to emerge from its rural origin. This slow emergence is understandable in view of the continuing role of agricultural exports as virtually the sole economic base but it is, nevertheless, unrealistic in face of the overwhelming predominance of employment opportunities in secondary and tertiary activities of urban areas. An important consequence of this

belated emergence is that our knowledge of our cities is rather elementary and our appreciation of the urban environment is uninformed. The study of urban processes in the New Zealand context has really just begun and, for this reason alone, it is hoped that this book will shed a little light and encourage further work. The data on which the study is based relates primarily to the year 1959 and it might at first appear to be out of date already. However this is a study of the nature, extent, and relationships of traffic movements in one city and, thereby, has a timeliness and timelessness that will, it is hoped, become apparent in the chapters that follow.

The collation and publication of studies undertaken by the Christchurch Regional Planning Authority in the preparation of a transportation plan, was suggested to the Authority early in 1962. I am indebted to my colleagues in the University of Canterbury who agreed to join with me in this task. Dr. L. J. King, who was at that time a Lecturer in Geography and is now Associate Professor of Geography at Ohio State University, wrote the draft of Chapter Two: Mr. R. G. Golledge, who was also a Lecturer in Geography and is now in the Graduate School of the State University of Iowa, wrote the draft of Chapter Three: and Mr. A. Williman, who is a Senior Lecturer in Civil Engineering, wrote the draft of Chapters Five and Six. As General Editor I have taken great liberties with their work and I appreciate their tolerance and understanding. If what appears in this book bears, at times, little resemblance to their original drafts, I must accept full responsibility.

This book has been written with the aim of providing a logical and coherent account of the first full study of traffic in a New Zealand city. It is neither a summary for popular consumption nor a technical manual, nor is it a critical review: rather it is offered both as a contribution to knowledge and as a service to the community at large. We have received full cooperation from the Christchurch Regional Planning Authority which made available the mass of material of their studies in various degrees of digestion. This material had been prepared by the Authority for specific practical problems and not with a view to publication. One persistent difficulty that faced us was the great volume of statistical data, some being reported statistics of various organisations, some being estimates based upon sampling of present traffic and other matters, and some being prognostications of future traffic, travel, land use, employment or the like. This data necessarily varies greatly in its degree of accuracy but it is logical and common practice, in reporting numerical data, to include only the number of significant figures whose accuracy is believed to be beyond dispute and this practice is particularly commendable in respect of future estimates. In this book it has not been found possible to follow a consistent policy. 'Working' figures have been taken from the records of the Authority and are included here without any editing but this does not imply that the estimates for 1980, for example, are to be considered accurate to the four, five or six figures which are used in some places. Rounding of the figures could have been done by the Authority's staff when the data was first derived but this would have been of no advantage for much of the work of computing was done by machine. In addition, rounding at this stage would have tended to introduce inaccuracies and inconsistencies into the final data. Alternatively, rounding could have been carried out by the authors of this book, but, to be accurate and logical, it would have required a great deal of research into the probable limit of accuracy of each set of data. This was considered to be neither possible nor necessary and the figures are given here as they were presented to the authors.

ACKNOWLEDGEMENTS

As this book goes to the press, it gives me great pleasure to thank all those who helped to make it possible. I am grateful to the Vice-Chancellor (Dr L. L. Pownall) and Council of the University of Canterbury for their approval of the participation of Mr Golledge, Dr King, Mr Williman and myself in the project and the use of typing, draughting and other technical services within the University. To my Head of Department (Professor R. S. Waters) and my other colleagues in the Department of Geography, I am particularly indebted for their understanding and for helpful advice on many points. Some of the attractive features of the book are due to the willing cooperation of Professor H. J. Simpson of the School of Fine Arts: in particular, Mr M. V. Askew, Senior Lecturer in Design, has given generously of his knowledge and experience. The skill of Mr Askew is to be seen in Plates XII (right), XIII (middle), XV, XVI (middle and bottom), XVII (middle and bottom), XVIII (bottom), XXII, XXIII (middle), XXVI (top and bottom), XXVII (top and bottom); that of one of his students, Mr M. Guy, in Plates III, XII (left), XVI (top), XVII (top), XVIII (top and middle), XXIII (bottom), XXIV, XXVI (middle). Plate VIII (middle) is by courtesy of the Housing Division, Ministry of Works. The Christchurch Regional Planning Authority was the source of Plates VII, VIII (top and bottom), X, XI (bottom), XIII (top and bottom), XIV, XIX (top and bottom), XXIII (top), XXVII (middle).

Without the friendly cooperation of Miss Nancy Northcroft, a Chartered Town Planner and Registered Architect, and Mr G. C. Suggate, a Design Engineer of the Ministry of Works, this book would not be in its present form. Both persons were associated with the Christchurch Regional Planning Authority at the time of the traffic investigations and were primarily responsible for their direction. It was Miss Northcroft, as Regional Planner in charge of the Authority's Staff early in 1962, who received my original suggestion for this publication and placed it before the Authority. Both Miss Northcroft and Mr Suggate shared their great practical knowledge with me on many long days during the months of editorial work: their patience, persistence and encouragement seemed endless. Many other persons have made critical contributions. Mr D. J. Edmondson, Regional Planning Officer of the Authority, wrote the draft of Appendices A and B, helped in proof reading and was my liaison officer in the Authority handling formal matters. Mr M. Douglass, recently appointed as Regional Traffic Engineer of the Authority, and Mr H. E. Surtees, Traffic Engineer of the Christchurch City Council, assisted in the clarification of several points. To Mr F. S. Robinson, Senior Planning Assistant of the Authority, fell the very important duties of supervising the team of draughtsmen, compiling and checking many Tables, and prime responsibility for handling all matters with the printers. Even a quick perusal of the Figures and Tables will indicate something of the magnitude of these tasks and the competence with which he and his team performed them. Mr E. J. Bradshaw, Chairman of the Regional Planning Authority, and Mr C. B. Millar, present Director of Planning, also read the manuscript critically and offered valuable professional comments.

The extent to which I have failed to profit from the good-humoured and understanding cooperation of all these people is to be measured by the inconsistencies of fact, the inaptness of form and the infelicities of phrase. This book is a product of collaboration because many have shared in the labour of preparing the manuscript: equally we are all looking forward to the day when it comes off the press. The printers are assured of our thanks and sympathy, and especially those of my wife.

Christchurch
18th January, 1965.

W. B. JOHNSTON

CHAPTER ONE

Towards the Future

THE CITY is the most complete modification of any part of the earth's surface that man has made through both his constructive and destructive activities. Here is to be seen the major expression of his material works. Here human beings are brought together in their greatest numbers and densities.

The city serves itself and its hinterland most successfully when all parts of the urban area are readily accessible to one another as well as to the surrounding rural area. Rapid and frequent circulation of people, goods and vehicles is vital for city life. The increasing mobility of people leads to more and more journeys for the satisfaction of business, shopping and social desires; travellers are demanding greater convenience of movement and this has generally been in terms of more frequent use of a rapidly growing number of motor cars. In making all these trips within the limits of the city and its suburbs there is natural competition for use of the means of transport. People cannot avoid getting in the way of one another. And thereby virtually all travellers are made aware of one of the recurring problems of urban places—the 'traffic crisis'.

These travel demands now and of the future are a measure of the prosperity and wealth of a modern city which functions best when ease of movement permits specialisation within its various parts to the profit of all. If the city is to grow and prosper, and if the citizens are to be busy and productive, there will be ever greater demand for movement. If the business heart of the city becomes strangled by traffic congestion on its streets as well as along the access routes to it, the whole structure of the urban area and its circulatory system will be drastically altered: the cost to the community is almost beyond calculation.

Christchurch is one of the cities of New Zealand that are having to prepare for the mounting volume of traffic on their streets. In a country of 103,000 square miles, 60 percent of the total population of nearly 2,500,000 in 1961 lived in

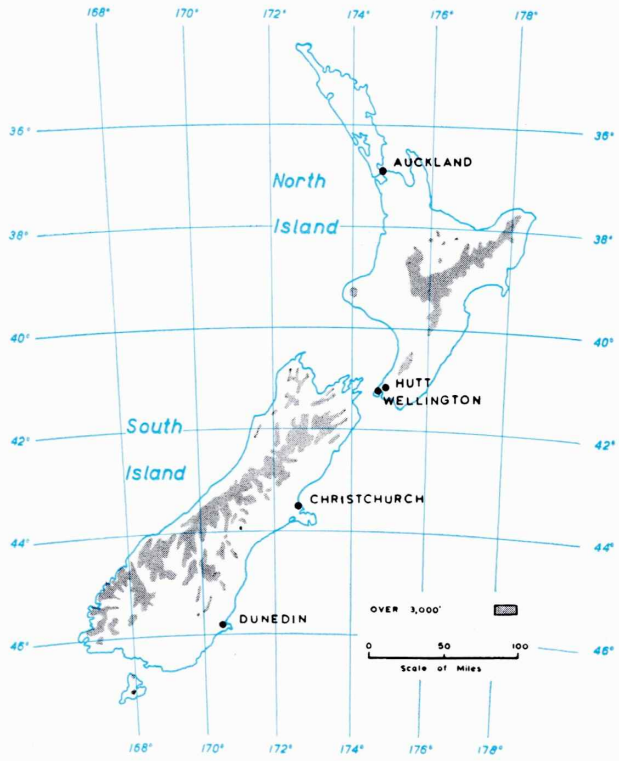


Fig. 1. NEW ZEALAND. The five Urban Areas contain over 40 per cent of New Zealand's population.

Urban Areas, that is in a central city or large borough together with adjacent areas regarded as suburban to it[1]. Within the five largest Urban Areas — Auckland, Christchurch, Wellington,

[1] *Population Census 1961*, Vol. 1, Wellington, 1962, p. 5.

Dunedin, Hutt (Fig. 1)—were over 40 per cent of New Zealand's population. Next to Auckland (nearly 500,000 people), Christchurch (over 220,000 people) was the second largest Urban Area.

Christchurch is the largest urban centre in the South Island of New Zealand. It has a population more than double its closest rival, Dunedin, and is distant from it by over 200 miles of road or rail (Fig. 2). The city is located midway along the eastern coast, on the margin of the Canterbury Plains, and separated by a narrow ridge of Banks Peninsula from Lyttelton, the major overseas and coastal port of the South Island (Fig. 3). Christchurch and Lyttelton are linked by a railway tunnel, by hill roads and, since 1964, by a road tunnel. The location of Christchurch has made it the dominant road, rail, shipping and air centre of the South Island.

THE PROBLEM

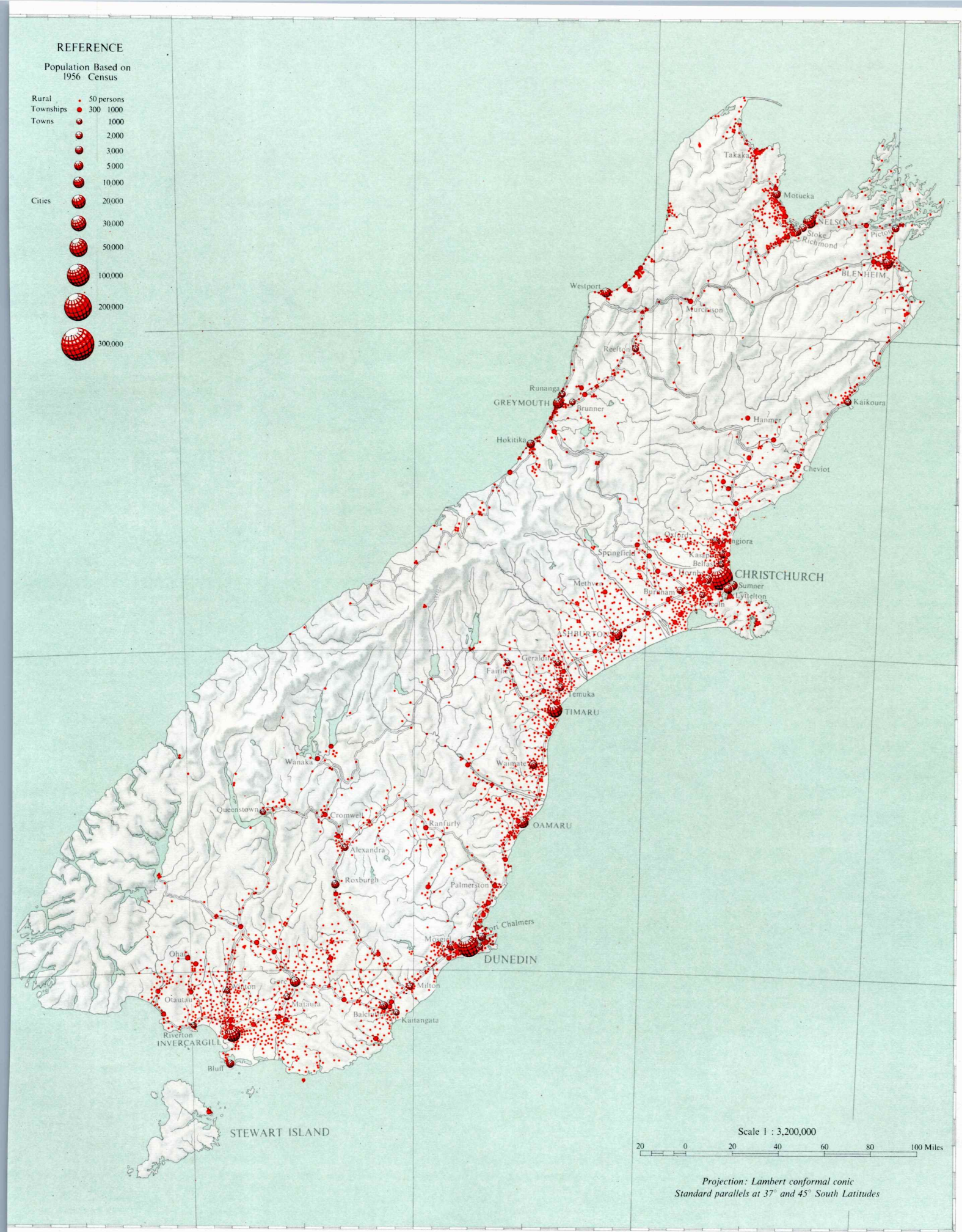
In Christchurch of 1959 there were over 200,000 people living within the built-up area of 50 square miles. And in going about their daily tasks, these people made almost half a million individual trips on an average weekday. Less than 10 per cent of these trips were made by pedestrians, all the rest involving vehicles of one sort or another. Over 40 per cent of the trips were made by car, one third by bicycle, and less than one fifth by public transport. In 24 hours there were over 220,000 movements by cars and trucks. The number of cyclists is a peculiar characteristic of Christchurch traffic. There were about 90,000 bicycles in the area in 1959—almost twice the number of motor cars—and the mixing of motor vehicles and bicycles creates serious difficulties in the central area of the city. Over the last 20 years however, there has been little if any increase in the number of bicycles in the city. What seems to be happening is that, as the city grows and the number of children increases, more and more of the cyclists are school children. In other words, former adult cyclists are now using cars.

These figures for travel and traffic are not large on a world scale. What gives them importance is that they occur within the confined space of the Christchurch urban area and that most of the trips are made during short time periods. It is the dual concentration in time and space which creates the transportation problem of Christchurch as in other cities of the world.

The realisation of increasing traffic congestion goes back many years as witnessed, for example, by the growth of traffic signals and the removal of trams. Earlier in the decade traffic counts in the city centre indicated the rapid growth of traffic. Counts of vehicles were made in 1952 and repeated in 1957 with the same location of census points, the same classification of vehicles, and covering a comparable time of year and period of day. Comparison of the two counts for the 12 hours from 6 a.m. to 6 p.m. on a weekday showed an increase of almost 35 per cent in movements to and from the central business area. Between 9 a.m. and 4 p.m. the percentage increase was below the average for the 12 hours: in contrast very high percentage increases in traffic were apparent from 6 a.m. to 8 a.m. and from 5 p.m. to 6 p.m. It was assumed that this concentration of increased traffic into three peak hours reflected the increasing use of more motor cars as a means of

Fig. 2. SOUTH ISLAND—POPULATION. Thirty per cent of New Zealand's population of two and a half millions live in the South Island, the larger of the two principal islands and some 58,000 square miles in area. The pattern of population distribution broadly indicates the extent to which European (predominantly British) people have been able to develop and use the land during their hundred and fifty years of occupancy. Most of 730,000 people live within 20 miles of the sea in a belt from Christchurch to Invercargill: elsewhere they tend to cluster on coastal or valley lowlands which are separated by great tracts of rugged, empty country. This distribution is also a reflection of the surface configuration of the island which is more clearly represented in Figure 3.
Christchurch is the largest urban centre in the South Island. It has almost one third of the island's population, is more than double its closest rival, Dunedin, and is separated from it by over 200 miles of road or rail.

(Map reproduced from *A Descriptive Atlas of New Zealand* by permission of the Department of Lands and Survey)


REFERENCE
Population Based on 1956 Census
Rural
Townships
Towns
Cities
50 persons
300
1000
2,000
3,000
5,000
10,000
20,000
30,000
50,000
100,000
200,000
300,000
Takaka
Motueka
NELSON
Stoke
Richmond
Picton
BLENHEIM
Westport
Murchison
Reefton
Runanga
GREYMOUTH
Brunner
Kaikoura
Hanmer
Hokitika
Cheviot
Springfield
Kaiapoi
Belfast
CHRISTCHURCH
Sumner
Lyttelton
Methven
Burnham
Geraldine
Fairlie
Temuka
TIMARU
Wanaka
Waimate
Queenstown
Cromwell
Ranfurly
OAMARU
Alexandra
Roxburgh
Palmerston
Port Chalmers
Mosgiel
DUNEDIN
Ohai
Milton
Otautau
Matatura
Balclutha
Kaitangata
Riverton
INVERCARGILL
Bluff
STEWART ISLAND
Scale 1 : 3,200,000
20 0 20 40 60 80 100 Miles
Projection: Lambert conformal conic
Standard parallels at 37° and 45° South Latitudes


Feet
7000
5000
3000
1000
Sea Level
Fathoms
100
250
500
750
1000
1250
1500
1750
2000
Cape Farewell
Whanganui Inlet
Farewell Spit
GOLDEN BAY
Cape Stephens
Separation Pt
D'Urville I
TASMAN BAY
TASMAN MTS
Karamea R
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VICTORIA RA
Teremakau R
Grey R
GREYMOUTH
Taramakau R
L Brunner
Ahaura R
Hanmer Plains
Clarence R
SEWARD KAIKOURA RANGE
Kaikoura Peninsula
Hokitika R
L Sumner
L Kaniere
Waiau River
Hurunui River
Abut Head
ALPINE FAULT
SOUTHERN ALPS
Mt Arrowsmith 8271
Gillespie Point
Mt Cook
Ashley R
L Coleridge
PEGASUS BAY
Waimakariri River
Heretaniwha Point
CHRISTCHURCH
Selwyn R
L Ellesmere
BANKS PENINSULA
Akaroa Harbour
TASMAN BASIN
Haast R
Jackson Head
Jackson Bay
Tekapo
TWO THUMB RANGE
Opuha R
Rakaia River
Ashburton R
Hinds R
Rangitata River
Orari R
Opihi R
Awarua Point
Awarua Bay
OLIVINE RA
Mt Aspiring
YOUNG RANGE
BEN OHAU RANGE
L Pukaki
Mackenzie Plains
Tengawai R
L Ohau
Ahuriri R
Waitaki Plains
TIMARU
CANTERBURY BIGHT
Pareora R
Milford Sound
L Wanaka
L Hawea
Clutha R
RIVERS HUNTERS HILLS
Hakataramea R
Sutherland Sound
Bligh Sound
George Sound
HUMBOLDT MTS
RICHARDSON MTS
HARRIS MTS
PISA RA
DUNSTAN MTS
HAWKDUN R
L Waitaki
Waihao R
Waitaki River
FRANKLIN MTS
STUART MTS
Caswell Sound
Charles Sound
Nancy Sound
Thompson Sound
Secretary I
Doubtful Sound
Daggs Sound
MURCHISON MTS
L Te Anau
LIVINGSTONE MTS
Double Cone 7688
L Wakatipu
EYREWELL RANGE
FRANKTON RANGE
CARRICK MTS
Upper Taieri Plains
KAKANUI MTS
Manuherikia R
Shag R
Taieri R
Breaksea Sound
Resolution I
Dusky Sound
L Manapouri
Mararoa R
TAKITIMU MTS
HUNTER MTS
L Monowai
Waimea Plains
Pomahaka R
OTAGO PENINSULA
DUNEDIN
Taieri Plains
Taieri River
Chalky Inlet
Preservation Inlet
Puysegur Point
CAMERON MTS
L Hauroko
L Poteriteri
Te Waewae Bay
Aparima R
Oreti R
Mataura R
Clutha River
Nugget Point
INVERCARGILL
Awarua Plains
FOVEAUX STRAIT
Toetoes Bay
Waipapa Pt
Long Point
Chaslands Mistake
Solander I
Codfish I
Ruapuke I
Mason Bay
Doughboy Bay
STEWART ISLAND
Port Adventure
Pegasus Bay
BOUNTY BASIN
Scale 1:3,200,000
20 0 20 40 60 80 100 Mil
Projection: Lambert conformal conic
Standard parallels at 37° and 45° South Latitudes

transport for those working in the city centre. Immediately outside the central business area, comparable counts in 1951 and 1957 indicated an increase in evening peak hour traffic of 50 per cent in six years. Another comparable count for 24 hours in 1951 and 1957 showed a growth of 90 per cent in traffic on the outskirts of the built-up area.

All the information gathered and analysed in many investigations before 1959 led to the assumption that a continuing and very large increase in vehicles and traffic on Christchurch streets could be expected in the near future. Although congestion was not at the time very severe or of long duration it was realised that this state of affairs would not last long. Christchurch appeared to be on the threshold of a major traffic problem, the nature of which would be aggravated by the number and frequency of intersections resulting from a rectangular street pattern, the flat site which gives little opportunity for natural separation of roads or railways from one level to another, the large number of bicycles, and the difficulty of redeveloping quickly enough the central business district in a way that would separate pedestrians from vehicles.

Increasing movement of people and vehicles along the streets and growth of the demand for space to park vehicles, means greater competition for use of all available facilities. People and their vehicles are bound to get in each other's way: thereby, all travellers become aware of the traffic problem. There is ample evidence to show

Plate I. '. . . . concentration in time and space . . . .'

that the number of vehicles on the streets and the trips that they make will increase rapidly in the future. To accommodate this traffic requires the development of a long range transportation plan which must be based on a careful forecast of the future requirements of the urban area, and, for this forecast, a detailed analysis of present movements by people and vehicles is essential.

An overall transportation plan for the future allows many individual and public decisions on travel and traffic and in many related fields, to be coordinated and directed towards a common goal. Detailed knowledge of the nature, purpose and extent of present traffic, and the establishment and acceptance of long range objectives,

Fig. 3. SOUTH ISLAND—PHYSICAL. High mountains of hard rock make up most of the South Island, dominated by the Southern Alps which culminate in Mt. Cook (12,349 feet above sea level). Alpine high country extends almost the full length of the island and contains shrunken remnants of formerly extensive glaciers. The largest of the South Island lowlands comprises the Canterbury Plains, an apron of gravel spread out in front of the Southern Alps and tying in the twin, extinct volcanoes of Banks Peninsula.

The mountain ranges lie athwart the prevailing westerly winds, a situation which results in a distinct wet and dry side effect. Whereas the western coast receives over 100 inches of rainfall a year, the Canterbury Plains are not only much drier (less than 30 inches a year) but have greater seasonal contrasts in temperatures, sunshine and winds.

In the process of settling the Canterbury Plains, the Europeans have replaced the indigenous tussock grasslands by an intensive and intimate association of exotic pastures, crops and livestock in which fat lambs are the principal source of income: at an early stage in the New Zealand export of frozen meat, 'Canterbury Lamb' became an international term synonymous with high quality.

(Map reproduced from *A Descriptive Atlas of New Zealand* by permission of the Department of Lands and Survey)

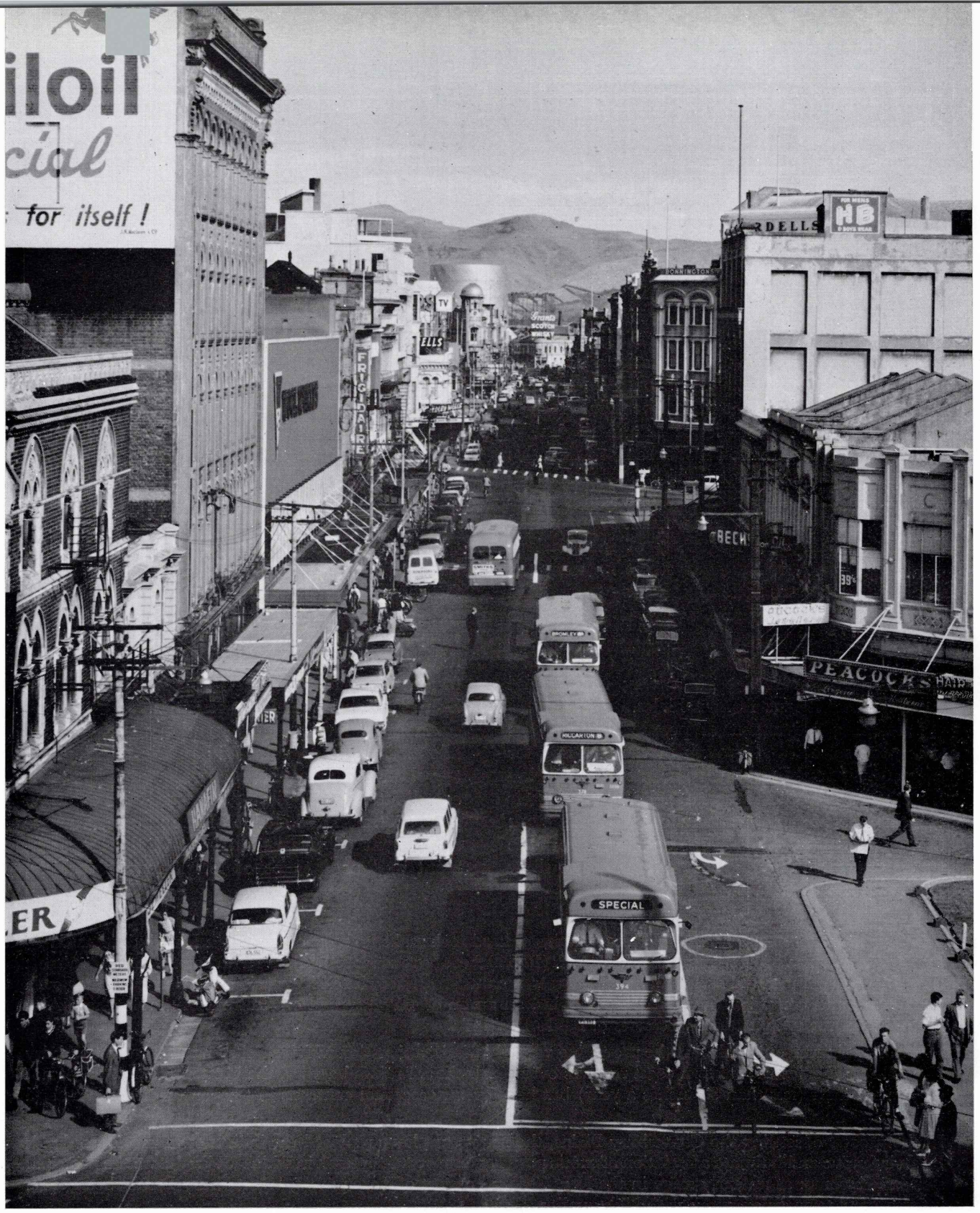

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Plate II. HIGH STREET, CHRISTCHURCH. Many of the features are characteristic of New Zealand city streets.

Whites Aviation Photograph

Plate III. THE CANTERBURY LANDSCAPE. From the western fringe of Christchurch (in foreground) across the Canterbury Plains to the snowy front ranges of the Southern Alps.

permit specific decisions on particular problems to be made on a more consistent basis and with greater public benefit.

In Christchurch in 1959, traffic was generally able to follow whichever routes it wanted to take for there was little frustration to travel on the streets. The importance of this situation is that it allowed the surveys of trips by people and vehicles to reflect the desired modes of travel and paths of movement whereas if there had been traffic congestion on the streets, the traffic and travel patterns would have been distorted accordingly. If the latter situation had existed, more refined measures of investigation and analysis would have been necessary in order to eliminate the distortion and, even allowing for this refinement, there would have been a much less sound base for making projections. The transportation

system in 1959 appears to have been reasonably successful in meeting the demands of urban travel. Therefore, in considering a traffic situation expected at a future period, it is reasonable to plan a transportation system that gives the citizens and the community a service comparable to that of 1959. In other words, the 1959 situation provides a valuable, comparative standard. For these reasons, Christchurch is fortunate in having carried out, when it did, the studies necessary for the development of a master transportation plan.

THE STUDY

The study of urban traffic rests on the central concept that the daily rhythm of movement within an urban area is orderly, measurable and rational. If travel and traffic were completely haphazard the planner's task would be hopeless. However, as most urban traffic displays a high degree of order, the regularity of movement can be measured, analysed, and related to other aspects of the urban area. The collected data can be used in the forecasting of movements and in the development of plans to meet future demands. The design of a study of this nature is greatly aided by the nature and results of experiments carried out elsewhere.[2]

The studies necessary for the preparation of a plan fall into four groups. First, there is the survey and analysis of basic factual material relating to the past and the present, including data about vehicles, travel, parking, carriage of goods, traffic volumes, existing street capacities, traffic generation of various parts of the urban area, distribution of population both as to residence and work place, and land use. Second, there is the forecast of future travel of people and movement of goods, and the estimation of traffic volumes resulting from these movements. Third, there is the design of solutions to overcome the deficiencies in the transportation system, deficiencies which are indicated by the estimated volume of future traffic. Finally, there is the analysis and assessment of alternative solutions and the statement of conclusions and recommendations.

[2] Of particular value were the studies entitled *Better Transportation for Your City—A Guide to the Factual Development of Urban Transportation Plans Accompanied by a Series of Procedure Manuals*, Public Administration Service, U.S. Department of Commerce and Bureau of Public Roads, Chicago, 1958.

SURVEY

Some of the most important information that was required concerned the origin and destination of all journeys or trips and, in each case, the mode of transport, the time of day and the purpose of the trips. In this context, trips include movements not only of vehicles, both for goods and passengers, but also of pedestrians, cyclists, passengers in cars, buses, trains and taxis. An inventory was made of data collected for a representative sample of movements by persons and vehicles within the Christchurch area and processed in such a way as to simulate the total pattern of movement on an average weekday. Analysis of the information indicated the places between which the major traffic flows occur at the present time and the magnitude of these flows. Similarly the surveys also provided data on parking.

The current information is the basis for future estimates from which an assessment can be made of the variety, scale and type of facilities likely to be needed at a particular time in the future. Forecasting from the existing base is much easier when there is a minimum of frustration to travel at the time of the surveys than when frustration is evident and non-uniform. It is believed that in 1959, at the time of the surveys in Christchurch, frustration was at a low level.

Direct expansion of the present number of movements is not by itself a satisfactory forecast. An urban area does not grow evenly in all its parts and therefore the travel patterns of the future will not parallel exactly those of the present. In addition, the modes and purposes of travel may alter as the city grows and transport technology develops. To make a reasonable forecast requires the description of the quantity, direction, mode and purpose of future travel and traffic.

Daily and regular movement of people and goods is inevitable where work places, shopping centres, recreational activities and other land uses are to be spatially separated. A basic assumption in making estimates of future travel was that there is a direct relationship between land use, as measured in various ways, and the amount and

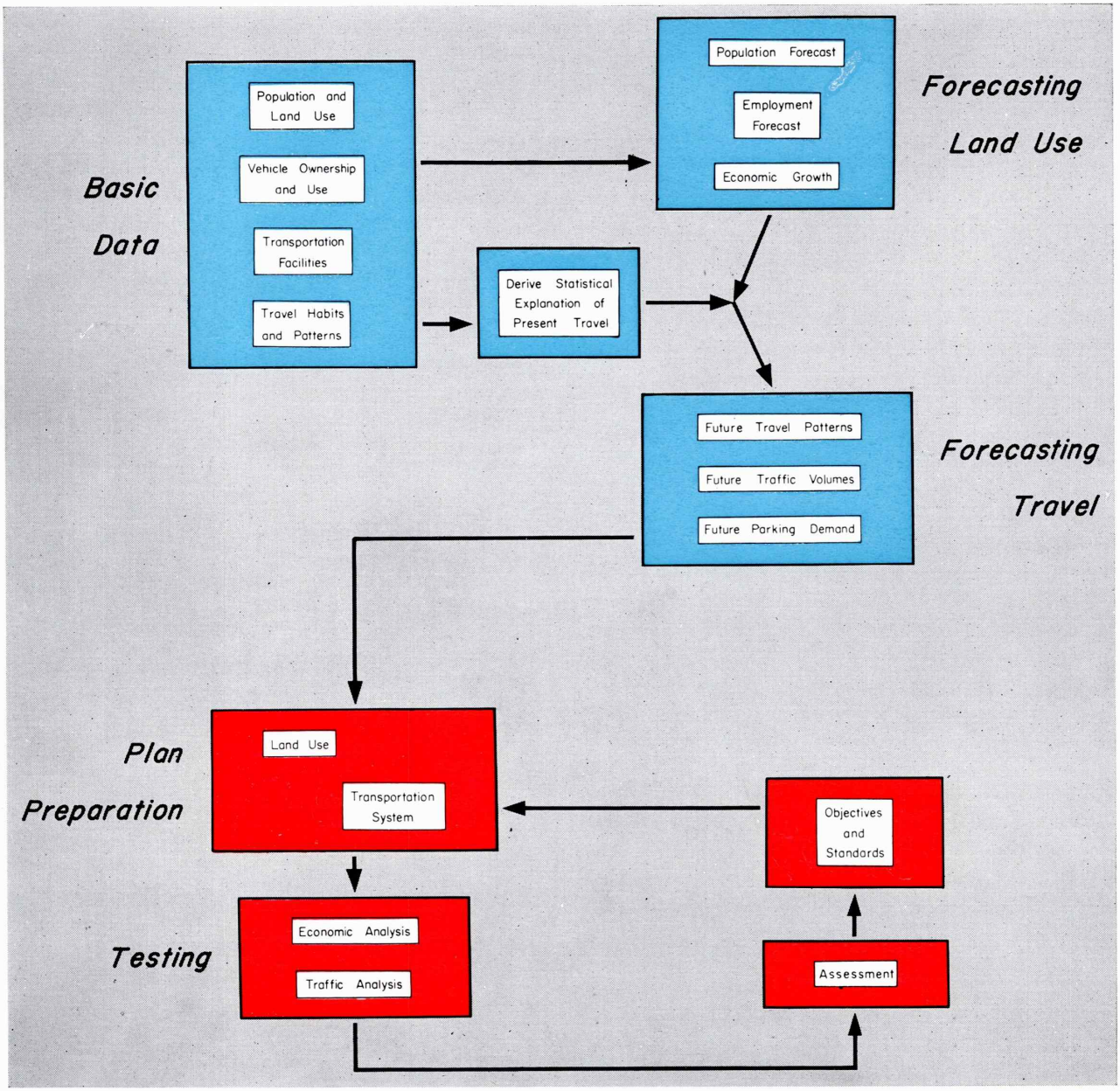

Fig. 4. The design of the study. All the stages in the development of a master transportation plan are shown. Those covered in this account are coloured blue.

distribution of travel. The ability to predict future land use with some reliability makes possible the prediction of future travel patterns. Therefore an inventory of land use was the second major survey. It provides data not only of the amount and distribution of urban land types but also in terms of other measures of the functional use of land, for example, number of households, employment in various categories, valuation, population numbers.

Finally an assessment was necessary of the

ability of existing facilities, including public transport, to handle increased travel and traffic. In large measure this required the survey of the present street system in terms of its carrying capacities. A comparison of the predicted traffic and the present street capacities provides a measure of the additional transportation facilities that will be required.

FORECAST

The forecast of urban growth requires the projection of population and employment. Both these estimates were related to the distribution of present land uses in order to locate the future distribution of residential and non-residential activities. This was an important step because the origin and destination of future travel depends upon the location of land uses as well as upon their type and intensity.

The translation of future land use—in a broad sense—into travel is, in theory, relatively simple but, in practice, it is very difficult to accomplish. In brief the method used was to derive formulae or other relationships which related present trip generation to land use and other selected variables. Using projected or estimated future values of these variables the same formulae or graphs, together with an estimate of the growth of the per capita ownership of motor vehicles, were used to make the forecast.

The predicted trip generation, in terms of numbers of person trips, had then to be distributed among the various parts of the city. Through a special study, that part of the trip generation which was associated with the city centre was derived as a separate quantity: for the balance of the trip generation an accepted method—the Fratar method—of distribution was used. The predicted travel must then be assigned to the present street system in order to discover the problem areas in the network. These problem areas become the critical points in the transportation system and indicate the needs to be met by the plan.

PLAN

It is possible to prepare a number of alternative solutions or plans to meet any predicted situation. However, careful judgement and considerable ingenuity are necessary in order to evolve transportation facilities that will permit the urban activities to continue to function adequately in the face of rising population and greater travel.

Certain objectives must be established and these strongly influence the plan. Alternative solutions are possible and the most likely plans require testing to see if they will be able to carry the traffic volumes that will be generated. The predicted travel must be assigned to the new network and the tests evaluated for the several alternatives.

The design of the study is illustrated in Figure 4 as a series of stages. First, there are the surveys of travel and traffic, population, land use and transportation facilities; next, is the preparation of the forecasts of population, land use and economic growth. The third stage is the use of these forecasts to estimate future travel; then alternative plans to meet the predicted traffic are prepared; and finally, these plans are tested in terms of their ability to carry the projected traffic and to meet the established objectives.

THIS ACCOUNT

The various steps in the development of a master transportation plan for Christchurch have been outlined in order to provide a broad view of the whole planning process. It is not the purpose of this account to cover all phases of the work. Rather the aim is to present a descriptive analysis of the investigations that have been made so that all who are interested in the end product—the master transportation plan—may obtain some understanding of the basis of the plan.

The account follows the stages already discussed.[3] An analysis of Christchurch today, particularly of land use and employment, is presented in Chapter Two. Chapter Three describes the present traffic and travel patterns, and establishes those characteristics which are most significant in explaining present trip generation and are, at the same time, useful in estimating future travel. The projections of population and economic growth of Christchurch are made in Chapter Four and, in Chapter Five, formulae and graphs to explain 1959 traffic are derived and the

[3] A valuable model is the *Chicago Area Transportation Study*, Volumes 1, 1959, and 2, 1960, Chicago.

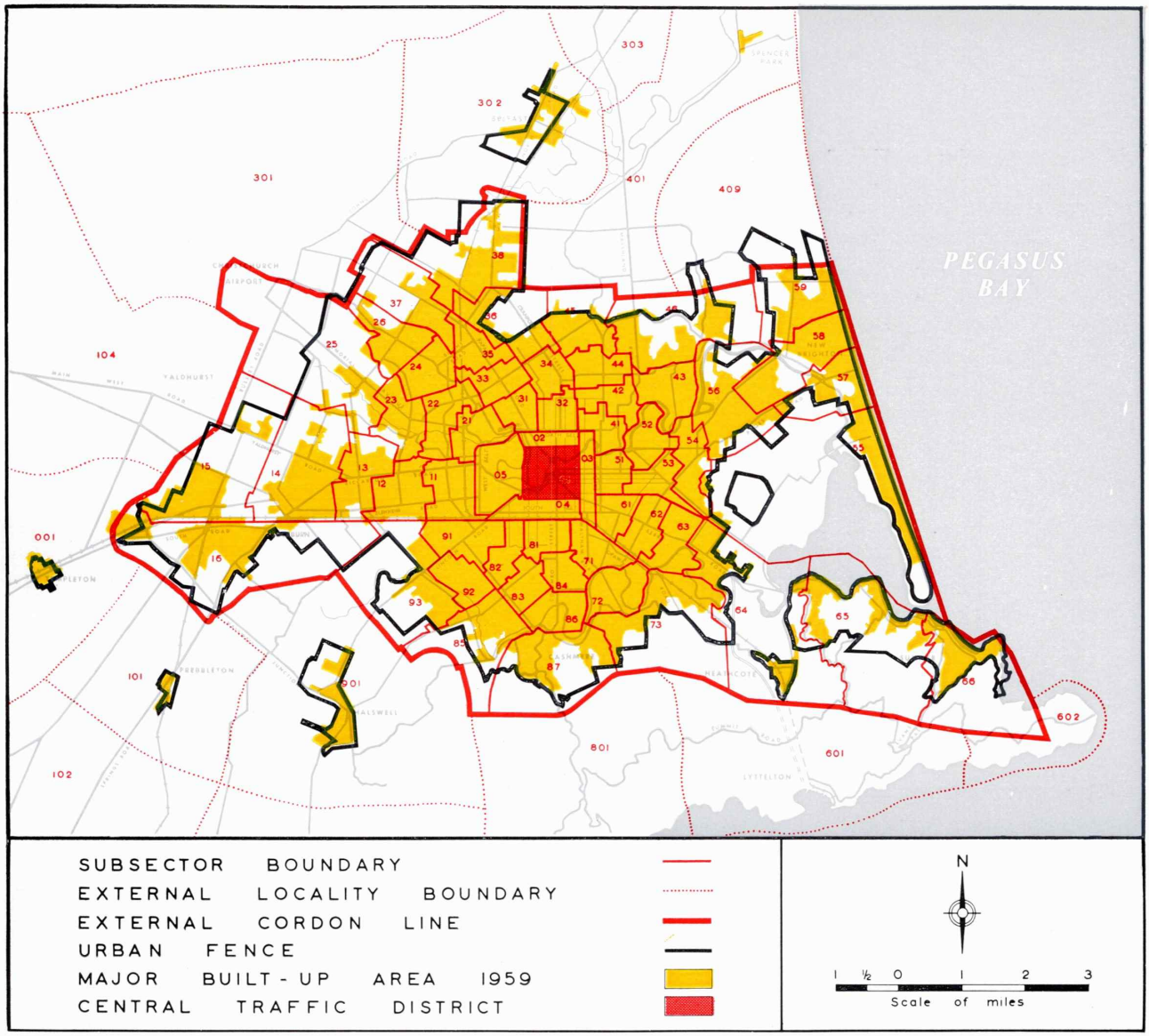

Fig. 5. Delimitation of major areal terms. A detailed reference map of sectors, subsectors, zones and adjacent localities is available in Appendix I (Fig. 75).

land use and related forecasts put into the formulae and graphs to estimate future travel and traffic. The analysis of estimated traffic flows on the basis of the present street system and capacities is made in Chapter Six and problem areas are located and described. The concluding Chapter Seven recapitulates the problem, the process of analysis and projection, and points forward to the preparation of a plan to meet the traffic of the future.[4]

[4] The outline of a transportation plan as a major network of roads is already before the community: see *Christchurch Master Transportation Plan*, Christchurch Regional Planning Authority, Christchurch, 1962.

DEFINITIONS

The final preliminary matter is the definition of various areal terms used in the collection of survey data and in this account (Fig. 5). The key term is the *Internal Area*. Its boundary—the External Cordon Line—was drawn so as to include the area which would contain most of the expected population growth of the next two decades but was adjusted in relationship to the road network. The External Cordon Line, as drawn, follows closely the urban fence, the line drawn in 1959 as the limit for urban development for the next twenty years. Within the Internal Area lies the *Central*

Traffic District—bounded by the Internal Cordon Line—which comprises a large part of the central business district and associated parking areas (Fig. 70 in Appendix B).

Because some of the traffic that moves within the Internal Area comes from outside or goes beyond its boundary, attention was also given to the *External Area*. The External Area includes the rest of the South Island but of greatest importance to Christchurch is that part adjacent to the Internal Area: data was collected for the whole or part when necessary.

To facilitate the geographical recording of material the Internal Area was divided into *sectors* and these, in turn, were subdivided into *subsectors*. The sectors were arranged about major routes radiating from the centre of the city. Extensions of these sectors into the External Area were divided areally into *localities*. The detailed location and description of subsectors and localities is shown on Figure 75 in Appendix I.

SUMMARY

The street system of Christchurch provides a number of alternative routes for any journey and this is an advantage for present traffic but a serious drawback in an attempt to analyse the present situation. Christchurch is also a city of bicycles but the bicycle population is almost static and the proportion of total urban travel undertaken by bicycle is diminishing. Parking in the central area is virtually at saturation point and any major change in the supply of parking space could materially change the travel pattern of the people who work in or use the city centre.

The investigation of Christchurch travel and traffic is based on the theory that the movements of people and vehicles are capable of explanation in rational terms. Measurements of the regularities of travel and their application to the development of a transportation plan require the design of a comprehensive study.

To enable a plan for the future to be prepared, the first essential is to understand the present situation together with as much past information as is available. In the next chapter the internal arrangement of the city is analysed and the succeeding chapter dissects present travel. Each aspect of the present situation is subsequently examined with a view to forecasting conditions and determining problem areas of the present transportation facilities in the light of future travel demands.

CHAPTER TWO

Land Use in Christchurch

IT HAS been often said that Christchurch is the most English of New Zealand cities, an impression which arises from the central dominance of the Anglican Cathedral, the architectural styles and garden settings of early public buildings or, perhaps more than anything else, the tree-lined, unhurrying Avon River winding through the city centre and suburbs. But in English towns few buildings are of wood and still fewer have the red and green corrugated iron roofs that are so common in Christchurch. In the rectangular street pattern, the relative spread of the built-up area, the single-storeyed residence set on its own plot with lawn and garden—in these and many other ways there is much that is more familiar to the American centre of comparable size than to an English city.

Yet Christchurch has distinctive features. It is a city of the plains and a city on a swamp although only on the southern margins where steep slopes rise sharply from the flat, has there been any serious physical limitation to expansion. The separation of the port of Lyttelton from the city of Christchurch by a narrow steep ridge has involved expensive tunnelling to provide rail and, since 1964, another road link. The original 1,000 acres of the planned town with its rectangular street pattern is now the inner city and at its centre is Cathedral Square, the focus of private and public road transport and the hub of the central business district. From the original 1,000 acres, which are still central in location to the urban area as a whole, growth has spread fairly regularly in all directions—eastwards some five miles to join the seaside suburbs; northwards three or four miles to invade market gardens and to seek an outlying industrial centre; westwards some five miles to surround one airport and press upon a second. Some three miles to the south growth has come sharply against steep slopes upon which are some of the highest-valued, residential areas. They occupy vantage points often several hundred feet above sea level whence they look out over the city and across the diversified crop and livestock farming patterns of the Canterbury Plains to the upstanding mountain front of the Southern Alps some 40 miles away.[1]

In 1959 there were about 200,000 people living in Christchurch. These people live and work within an area of a little more than 50 square miles which is contained by the urban fence. However only two thirds of this area is at present developed for urban purposes. The people of Christchurch then, occupy a developed urban area of 33 square miles.

The greatest user of urban space is the home; 50 per cent of the land developed for urban purposes is residential in function. Next in importance and using almost one third of the developed land are streets, the avenues for movement of people, vehicles and goods. The total of all other forms of land use, including industrial, commercial, and open space, is equivalent to only two thirds of the area in streets.

Urban activities tend to separate themselves according to different locational preferences. Manufacturing plants require good transport links to either the main railway or principal highways; retail firms must be accessible to the consumer; and residences seek their own desirable districts. Because these activities are spatially separated, people must move for their daily work and pleasures. Therefore travel is in large part a reflection of the internal structure and functioning

[1] General location and land use maps of Christchurch and adjacent areas are available for reference in Appendix I. The central business district of Christchurch is compared to the central business district of American cities of comparable population size in Appendix B.

Whites Aviation Photograph

Plate IV. CHRISTCHURCH FROM THE NORTHEAST. The inner city, traversed by the Avon River, is central in the urban area: Hagley Park is prominent middle right: the western slopes of Banks Peninsula intrude upper left. In the distance is coastal Lake Ellesmere and beyond is the Pacific Ocean.

of a city and varies with the type, quantity, location and intensity of land use. Conversely, the internal structure of the city itself is a function of circulation. Because of this interrelationship between land use and travel, the starting point of this transportation study is an analysis of the land use patterns.

THE SETTING

Christchurch is located on the eastern seaboard of the Canterbury Plains. The greater portion of the site is a low flat plain which nowhere rises 150 feet above sea level: however, the southern margins embrace the northward trending spurs of the hilly volcanic complex known as Banks Peninsula (Fig. 6). In this southern portion of the area elevations rise to about 1,200 feet and the local relief is frequently very steep. Despite the presence of this hill barrier to the south, the growth of the built-up area of Christchurch has not been seriously handicapped by any limitations of the physical environment. At the same time, there are some more subtle variations in physical factors, particularly structure and soils, which have affected the pace and direction of development.

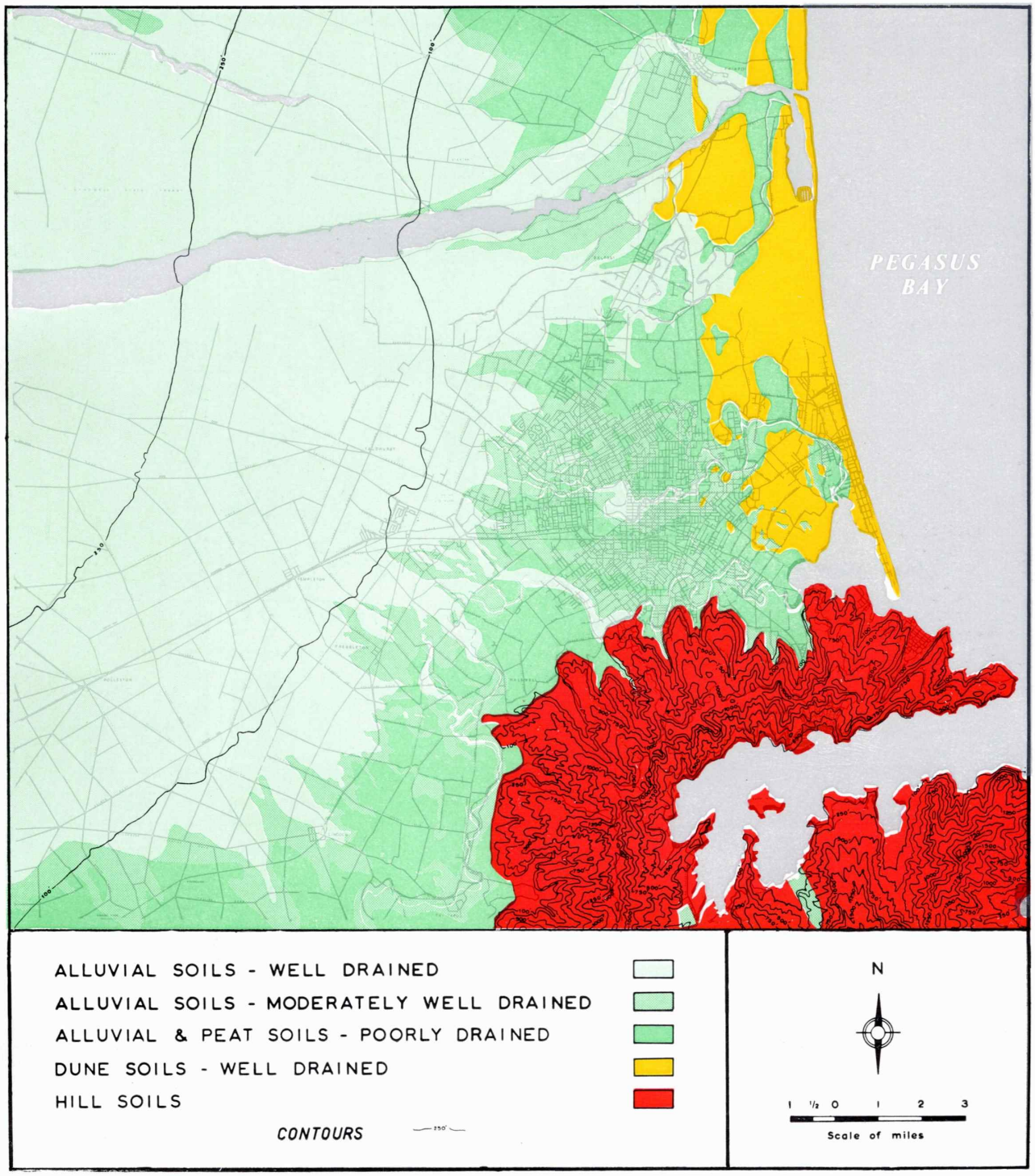

Fig. 6. The site of christchurch. The major contrast between the site characteristics of hill slopes and low plain is at once apparent, but there are also several distinct land units within the plain.

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Plate V. THE PORT OF LYTTELTON. A steep ridge of Banks Peninsula separates Lyttelton (in foreground) and Christchurch (in distance) which are linked by hill roads, a rail tunnel and, since 1964, a road tunnel.

The apparent flatness is deceiving and tends to obscure the fact that there are several distinct land units (Fig. 6). In the west and north there are the alluvial gravels of the Canterbury Plains proper, more specifically those of the Waimakariri alluvial fan. These gravel tongues are areas of well-drained soils which vary considerably in fertility. Urban development in these areas has been fostered on the one hand by the availability of excellent drainage facilities while on the other hand it has been accompanied, at least in its early stages, by the necessity for sinking deep wells for water supply. Forming a wedge between these alluvial gravels and the volcanic ridges of Banks Peninsula is a lowland composed of marine and alluvial silts, swamp deposits including peat, and wind-blown sands. This area is at present drained by the Avon and Heathcote Rivers.

As would be expected, the sand dunes are concentrated in a wide band along the coastal margins of the area. Much of this dune association has already been built upon, the advantages of excellent drainage apparently outweighing the limitations of poor soil conditions. Sand dunes

Whites Aviation Photograph

Plate VI. Coastal suburbs of christchurch. North Brighton (in foreground), playing fields, New Brighton (with pier) and South Brighton: beyond is the estuary overlooked by hill suburbs.

are also found in the northwestern sections of the area. Here, however, they represent deposits of wind-blown alluvial sand from the Waimakariri River and generally they extend in a linear arrangement into the suburbs of Papanui and Fendalton, and a part of Paparua County.

The greater part of the lowland wedge is an area of highly fertile loam soils which frequently require improved drainage although this is not everywhere the case. Interspersed among the loam soils are several significant peat deposits. When drained, the peats are excellent soils and in the Marshland area particularly, they have been extensively developed for market gardening purposes. Even here however, there is a steady encroachment of urban buildings.

URBAN GROWTH

The whole of the urban development is represented by the City of Christchurch, the Boroughs of Riccarton and Lyttelton, and the contiguous portions of Waimairi, Paparua, Halswell and Heathcote Counties (Fig. 7).

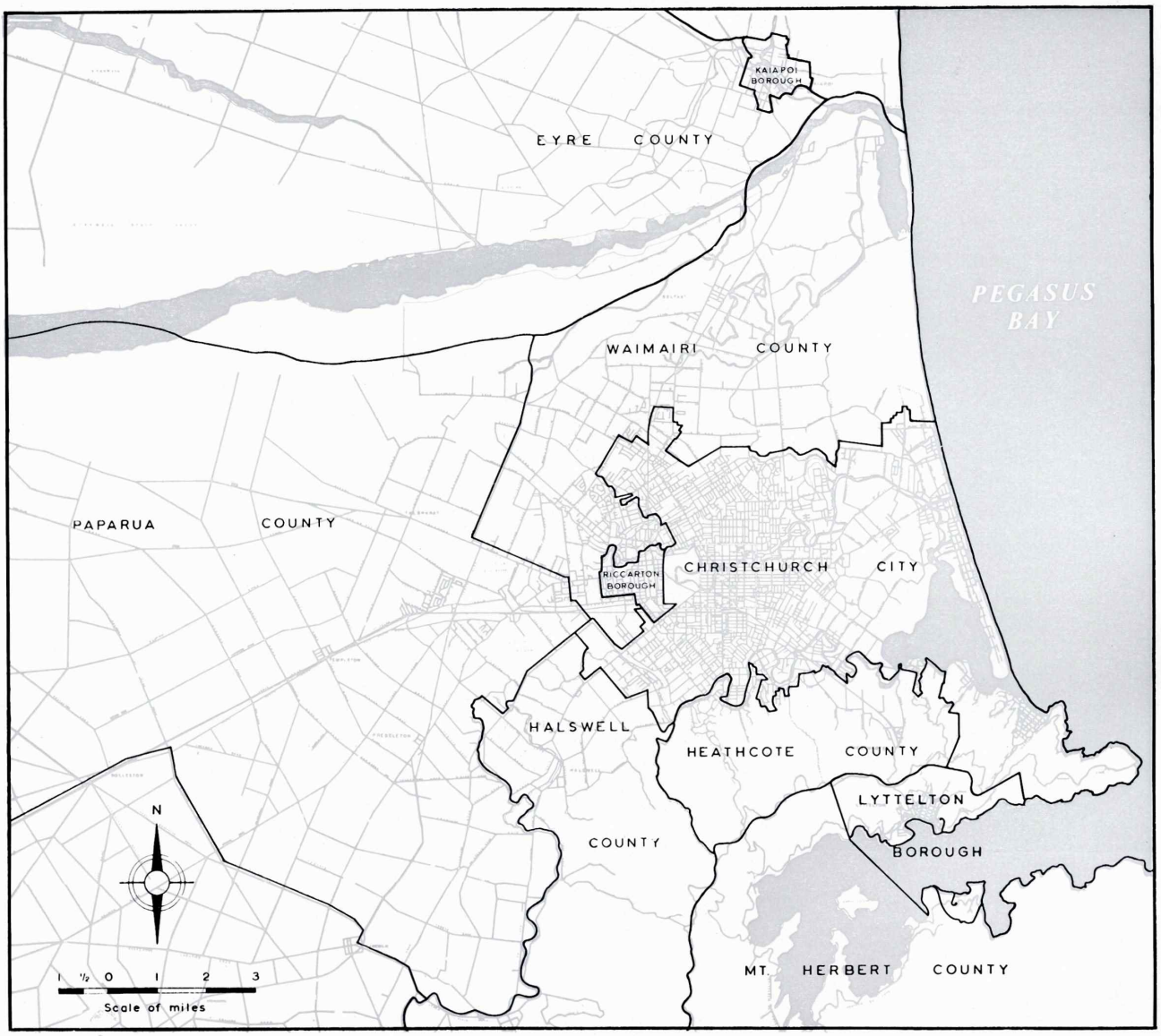


Fig. 7. Administrative units of the Christchurch area, 1959.

When viewed as a whole, the developed urban area appears to be roughly circular in shape, although several well-developed tentacles of urban land use serve to disrupt this overall symmetry (Fig. 8). Nevertheless, at first sight there does appear to be some evidence in favour of the notion that a city grows outwards in a series of rings around an original nucleus. In the case of Christchurch this nucleus was the area of 1,000 acres which Captain Thomas reserved for a city in his 1849 survey, immediately preceding the settlement of Canterbury. It was approximately this same area, bounded on the north by Bealey Avenue, on the east by Fitzgerald Avenue, on the south by Moorhouse Avenue and on the west by Hagley Park, that was officially created a borough

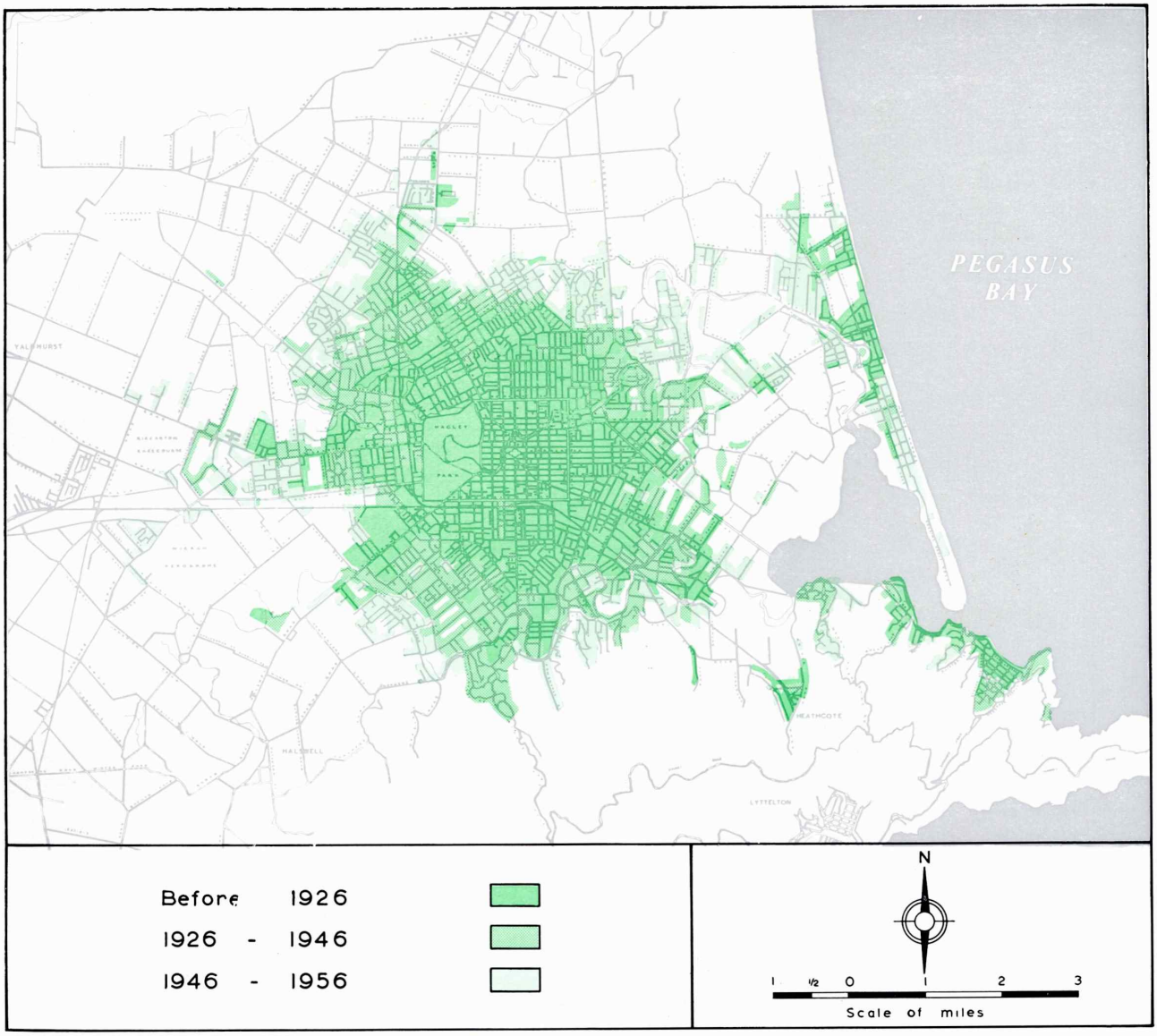


Fig. 8. PHYSICAL GROWTH OF CHRISTCHURCH TO 1956. By 1926 the urban frontier had invaded much of the area built upon by 1956.

in 1868 under the terms of New Zealand's first Municipal Corporations Act.

As an administrative area Christchurch City grew steadily in the decades following its incorporation as a borough (Fig. 9). By the mid-1920's the City comprised an area of 10,360 acres. Indeed by 1926, the greater part of the present built-up area had already been invaded by some form of urban development and much of the growth in subsequent decades merely filled in some of the gaps left by this initial advance of the urban frontier (Fig. 8).

The decade 1930-40 was a comparatively stable one as far as the growth of the City was concerned, but in the following decade and a half the area of the administrative City was more than doubled.

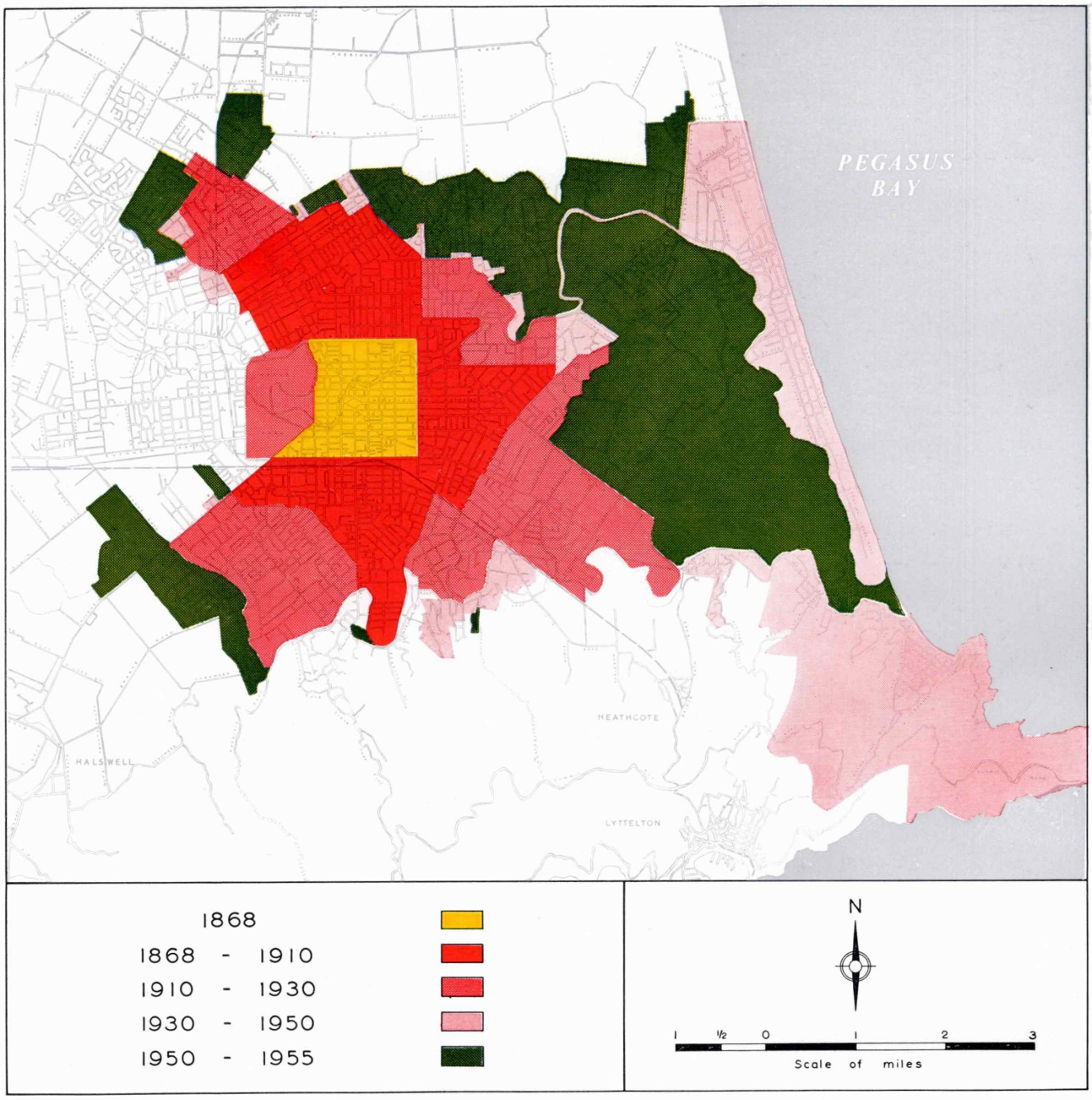


Fig. 9. Historical growth of the administrative city of Christchurch, 1868-1955.

This phenomenal increase was largely attributable to the addition of the Boroughs of Sumner and New Brighton along with large sections of the Waimairi and Heathcote Counties.

By 1956 the limits of the built-up area had also shown some considerable changes from the 1926 position. While much of the newer growth, as already noted, contributed to a filling in of the existing frontier, there were in addition significant advances made into rural areas particularly in the

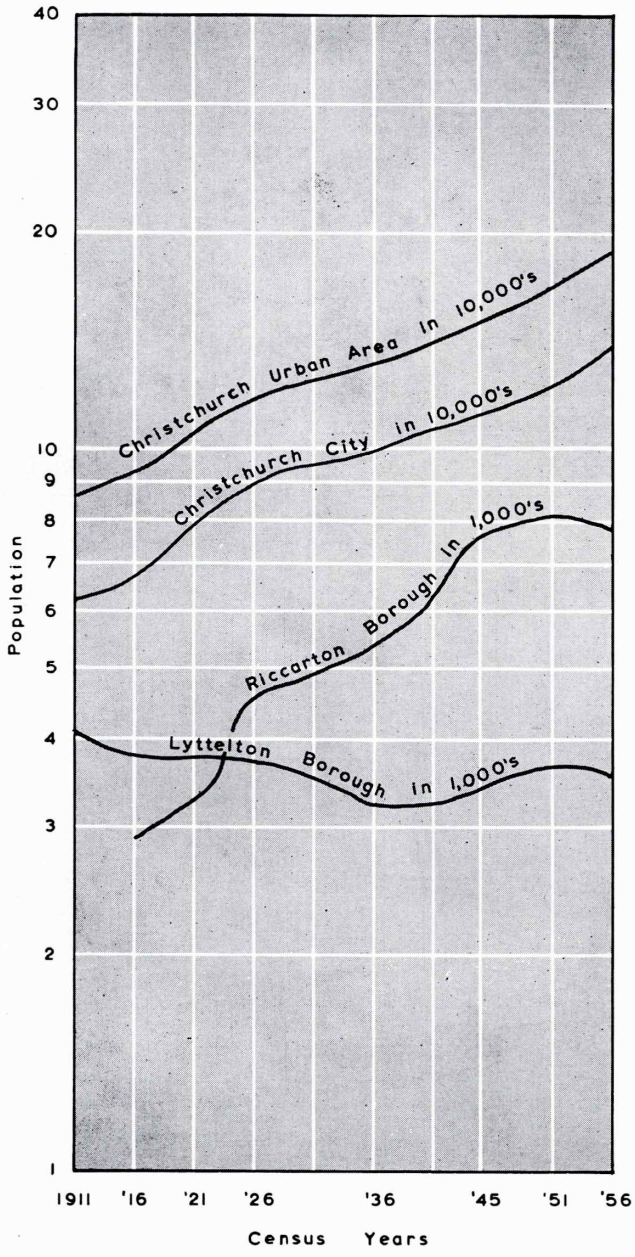


Fig. 10. POPULATION GROWTH OF THE CHRISTCHURCH URBAN AREA, 1911-1956.

Note: Those portions of adjoining counties that are within the Urban Area are not shown separately on this graph but their populations are included in the line for the total Urban Area. Riccarton Borough was constituted in 1913.

Source: *Population Census, 1956*, Vol. 1, Wellington, 1957.

north, northwest and southwest. A great deal of this development was made possible only by the marked expansion which occurred in the level of municipal transportation services and in the number of privately owned motor vehicles.

The spread of the built-up area of Christchurch occurred largely in response to the quite substantial population increases which were experienced (Fig. 10). By 1926 the population of the Christchurch Urban Area, that is to say Christchurch City along with the Boroughs of Riccarton and Lyttelton and portions of the adjoining counties, stood at 118,708, which reflected an average annual increase of around 2.5 per cent during the preceding ten years. However, in the face of subsequent economic depression and World War II, this high growth rate was not maintained and in the two decades immediately prior to 1945, the average annual rate of increase fell below 1.5 per cent. The postwar years witnessed a resurgence of population growth and the rate of annual increase has consistently remained above 2 per cent. As a result, the population size of the Urban Area in 1956 was in excess of 190,000.

As the population has grown and the built-up area has expanded, so too has the movement of people and goods increased in both volume and complexity. Urban development does in fact imply extended transportation facilities, for transportation is essentially the life blood of the body of the city. It not only sustains growth, but it enables the city to function successfully as a whole. Therefore, in order to understand the detailed system of transportation in Christchurch, it is essential to know the character of the city within which this system operates. Up to this point the urban area has been treated as a whole, but the time has now come to examine it in much finer detail.

LAND USE

By far the greatest proportions of Christchurch's population and traffic are concentrated in an area of some 50 square miles, which is itself focused on the central district, the original nucleus of 1,000 acres. For the purposes of the transportation study the Internal Area—for all intents

and purposes the major built-up area—was divided into 59 subsectors each of approximately 1,000 households. Preceding the traffic investigation, a detailed study had been made of the land use characteristics of the major built-up area, that is the area within the urban fence (Table 1). To ensure comparability with the traffic patterns presented later in this study, the results of the land use survey have been summarised and presented within the framework of the subsector division[2] (Table 43 in Appendix H). The detailed land use

[2] In analysing the land use maps it is important to remember that subsectors are *not equal in area* but are drawn on the basis of approximately 1,000 households each.

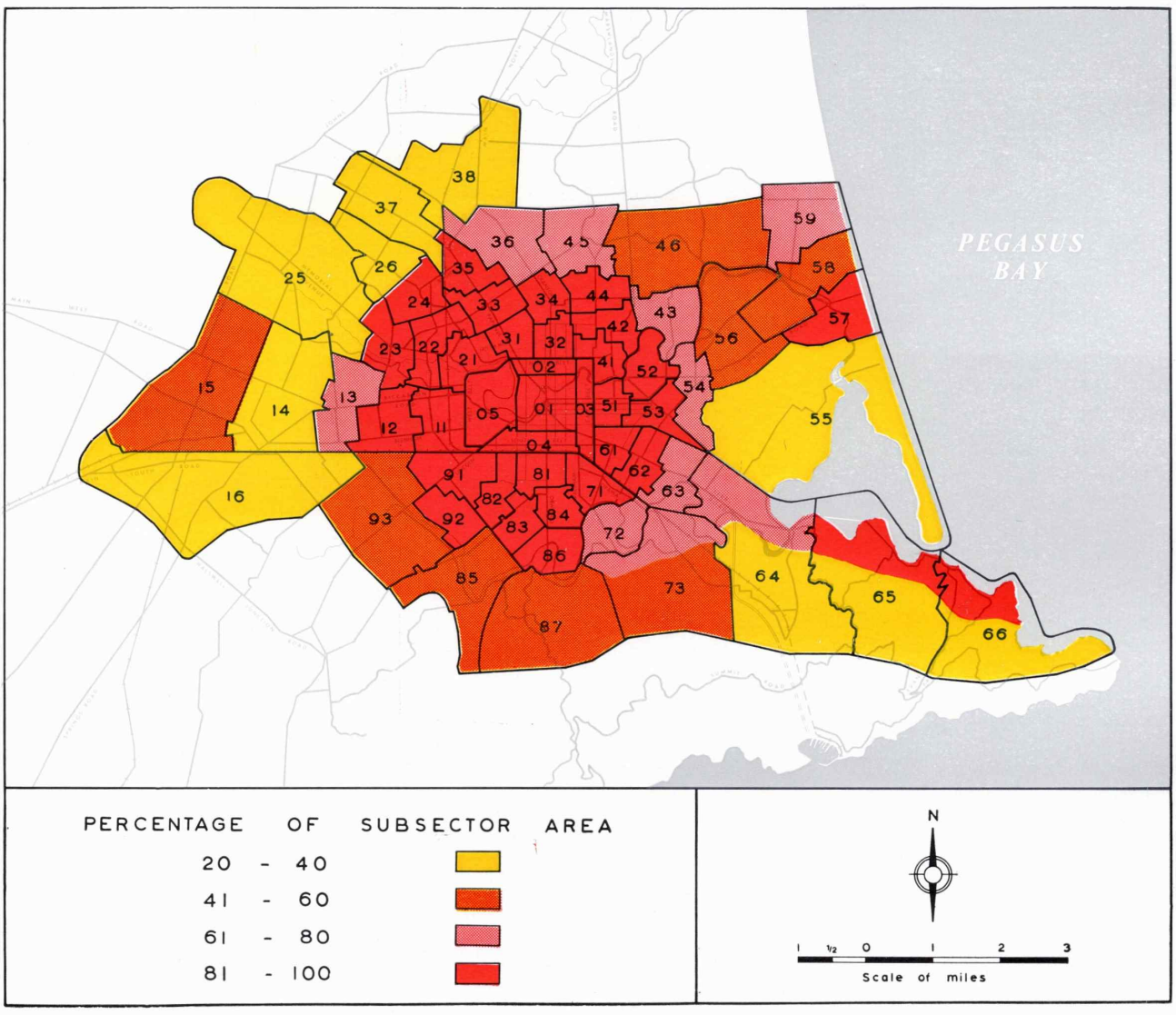
Fig. 11. URBAN LAND USE, 1956. The development of the Internal Area for urban purposes is by no means complete. *See Table 43 in Appendix H for details by subsector.*

TABLE 1

LAND USE WITHIN THE URBAN FENCE*: 1956

Land Use	*Area in Acres*	*Percentage of Total Area*
Residential	10,740	32.6
Commercial	233	0.7
Industrial (including Railways)	1,366	4.2
Public Use and Utilities ..	1,118	3.4
Open Space	1,683	5.1
Streets and Drains ..	6,140	18.6
Total Developed for Urban	21,280	64.6
Undeveloped for Urban ..	11,649	35.4
Total Area	32,929	100.0

* This table is based on a land use survey in 1956. See Table 43 in Appendix H for subsector details and the relationship of the urban fence to the Internal Area. The boundary lines are broadly similar as can be seen in Figure 5.



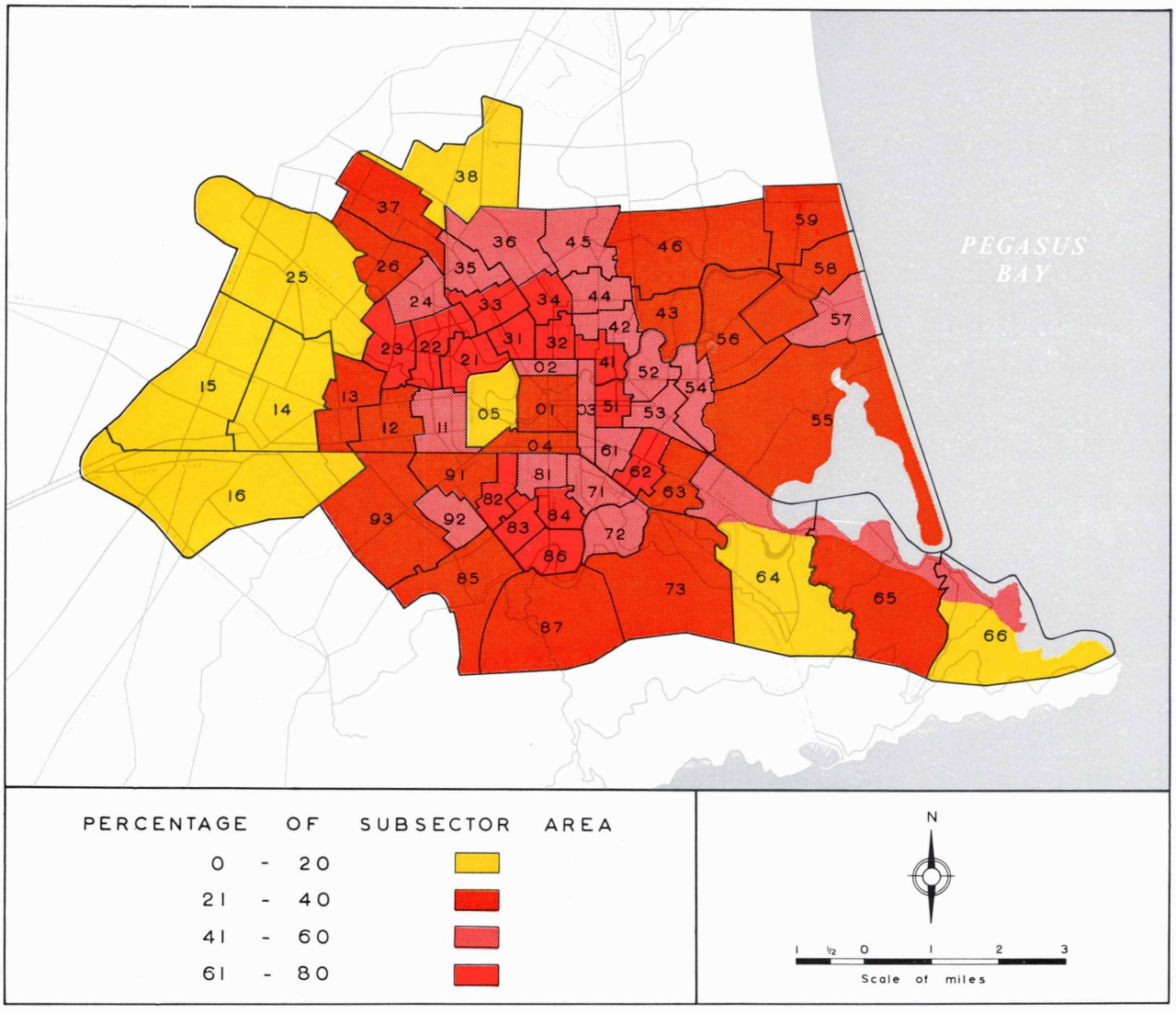


Fig. 12. RESIDENTIAL LAND USE, 1956. *See Table 43 in Appendix H for details by subsector.*

map has been generalised and reproduced in Appendix I which also contains a reference map of Christchurch and adjacent areas (Figs. 76 and 77).

It is significant to note that even within the Internal Area, development for urban purposes is by no means complete (Fig. 11). As might be expected, the hill areas in the south and the areas surrounding the estuary are comparatively undeveloped. Similarly in the west, northwest and northeast, there are large areas which have still to feel the full impact of urban development. In addition to these undeveloped, marginal areas there is still land awaiting urban development within the main built-up area.

RESIDENTIAL LAND

Within the Internal Area residential land use is the most extensive form of urban development and nearly one third of the total area is devoted to this type of land use, although Figure 12 reveals that the relative importance of the residential function varies considerably among the subsectors. There is a noticeable similarity between the maps of residential land use and developed land if the central area is disregarded. This correspondence is not surprising in view of the fact that residential land use is generally the basis of urban development and implies the presence of many of the other types of land use which are considered separately here.

Plate VII

Inner City

Early Residences

Workers' cottages, now near the end of their life

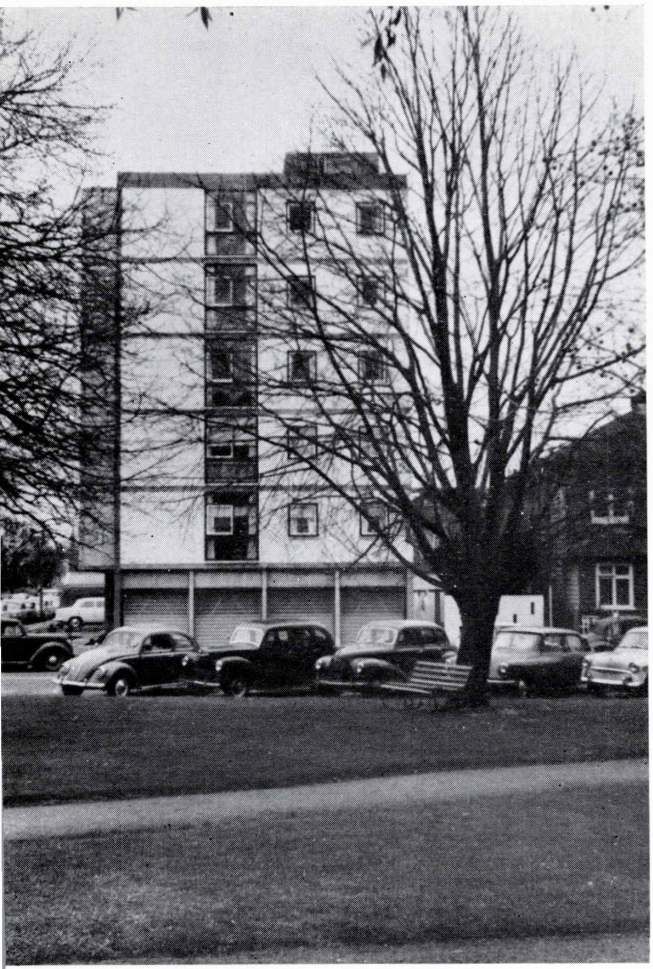
Town houses, now often in flats

Spacious home and gardens, now often occupied by social institutions

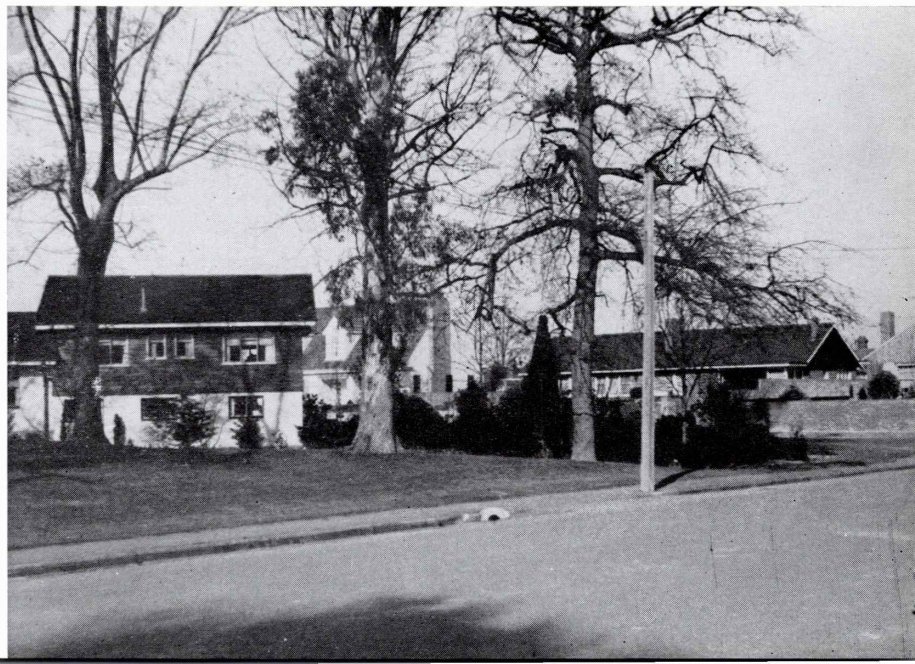
Plate VIII

Modern Residential Development

State housing



Inner city apartments



Private development

In other words, commercial functions, public buildings, open spaces (for example parks and playing fields) and streets are always associated with residential developments.

In the centre of the city commercial, industrial and public uses largely exclude the residential function (Appendix B). The economics of land use competition provide an obvious explanation for the comparative unimportance of the residential function in these central urban areas. Urban land use functions compete for the use of the land within a city in the same way that the various types of farming compete for agricultural land. The activity which can afford to pay the highest price for a piece of land will enjoy the use of that land to the exclusion of all other functions in the absence of other controls. To the extent that the central area of any city or borough is generally the point of maximum accessibility both from within and outside the larger urban area, then the various urban functions compete for the right to locate in that central position and thereby enjoy the advantages of this accessibility. Commercial and industrial activities which yield a comparatively high return per acre can obviously compete more successfully for this valuable central location than can the residential function, which yields a much lower return per acre. For the same reason, residential land use is often forced out of an area by higher rent-yielding functions. This process of invasion appears to have been at work in the areas to the south and southeast of the central core. Municipal legislation in the form of zoning ordinances serves as a check on this free interplay of economic forces.

The fact that residential land use is often concentrated in the outer areas of a city, away from the more central commercial and industrial areas with their employment opportunities, is in large part responsible for a city's traffic problems. The daily journey to and from work is an important component of the urban traffic volume.

STREETS AND OPEN SPACE

Streets (including drains) are the second largest users of land and the pattern is very similar to that of urban development. Hagley Park (subsector 05) naturally stands out as an exception to this generalisation.

Open space in the form of sports grounds, parks and special reserves accounts for five per cent of the area. Of the total 1,683 acres devoted to this type of land use, 439 acres comprise Hagley Park, while Rawhiti Domain and the Addington race track-showground account for a further 140 and 160 acres respectively. On the subsector level the distribution of open space does not appear to be closely related to any of the other land use patterns.

INDUSTRIAL LAND

Industrial land use including railway facilities, occupies almost as much land as does open space (Fig. 13). However, in this case the distribution pattern appears to be related in part to a specific factor, the availability of transportation services. A large proportion of the 1,366 acres devoted to industrial purposes in Christchurch is located adjacent to the main trunk railway line extending from the Heathcote Valley in the southeast to Islington in the west. This association of industry and rail facilities stems from an economic desire to minimise the transportation cost associated with the production and distribution of the manufactured goods. A similar association of industry and rail transportation occurs along the main north railway immediately west of Hagley Park. In recent years road transport has appeared to exert an even greater pull on industry than has the railway. The manufacturing district which is developing along Blenheim Road is the most striking example of this, although industry has been associated with the main north and south road outlets for some time. In the southern part of the central business district and adjacent areas, a broad belt of industry also relies upon road transport. Elsewhere in the city industry is concentrated in rather small and localised areas as, for example, the engineering workshops associated with the International Airport.

OTHER USES

As was the case with open space, public land use does not appear to be closely related to any of the other land use patterns. The largest single area

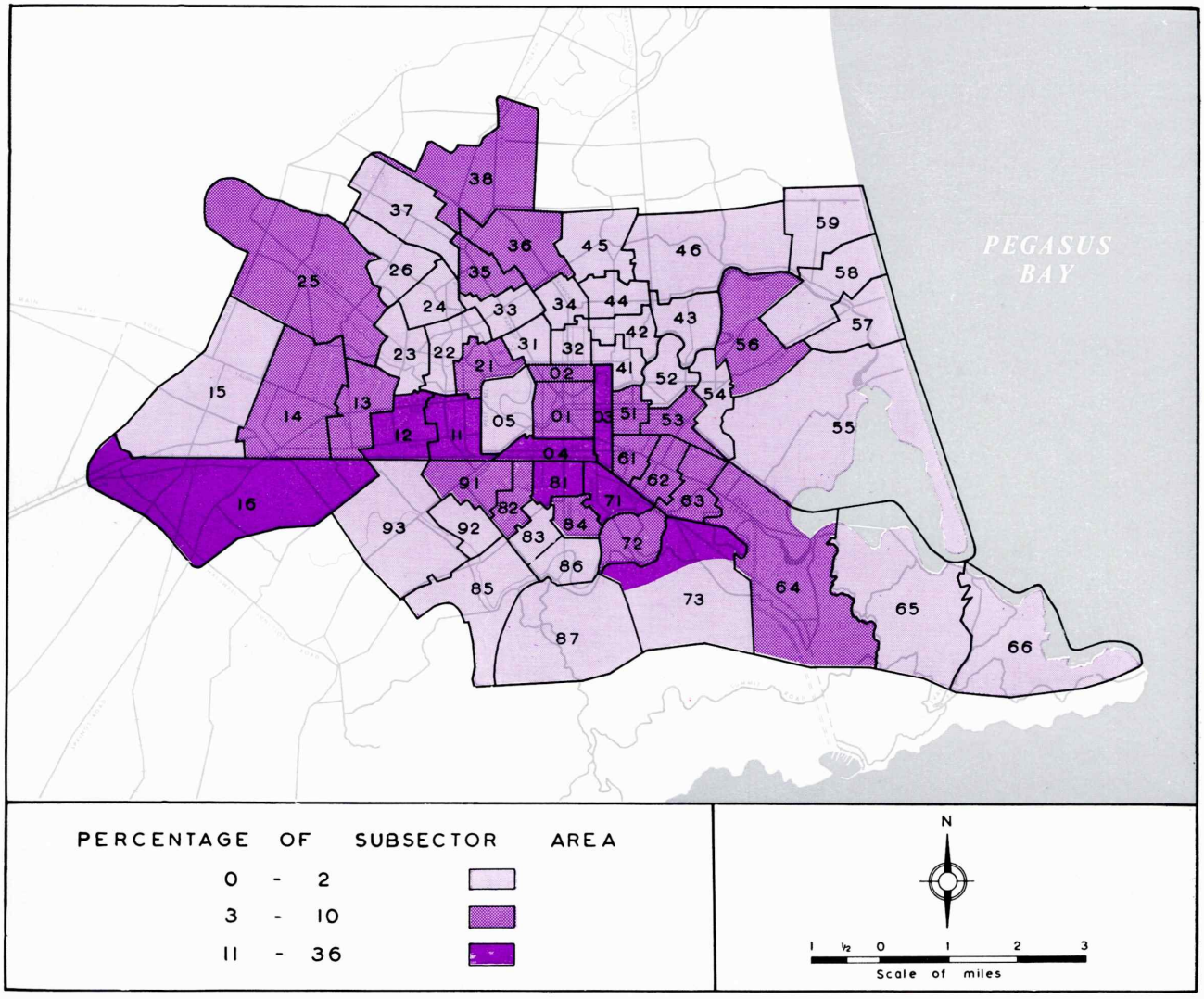


Fig. 13. INDUSTRIAL LAND USE, 1956. *See Table 43 in Appendix H for details by subsector.*

devoted to this type of land use occurs on the hills in the south where the Cashmere Sanatorium is located. Other concentrations of this type of land use within the built-up area are mainly associated with the location of administrative, judicial and military offices, education and cultural institutions, hospitals, churches, clinics, cemeteries, halls and public utilities.

There remains only commercial land use to be considered. Commercial functions account for less than one per cent of the major built-up area of Christchurch, but they make a very important contribution to the general economic life of the city. The pursuit of commercial activities does in fact generate much of the capital flow which sustains the urban economy. While commercial functions require only small amounts of land, they must be advantageously located with respect to the demand. Commercial functions therefore compete very strongly for the most accessible locations, and it is no coincidence that in Christchurch these functions are highly concentrated in the central core (Fig. 14). The secondary commercial centres of Riccarton (subsector 11), Sydenham (subsector 81), Papanui (subsector 35), New Brighton (subsector 57) and Sumner (subsector 66) are also easily recognised. This concentration of commercial functions also contributes very significantly to the traffic flow patterns of a city, in that it gives rise to the

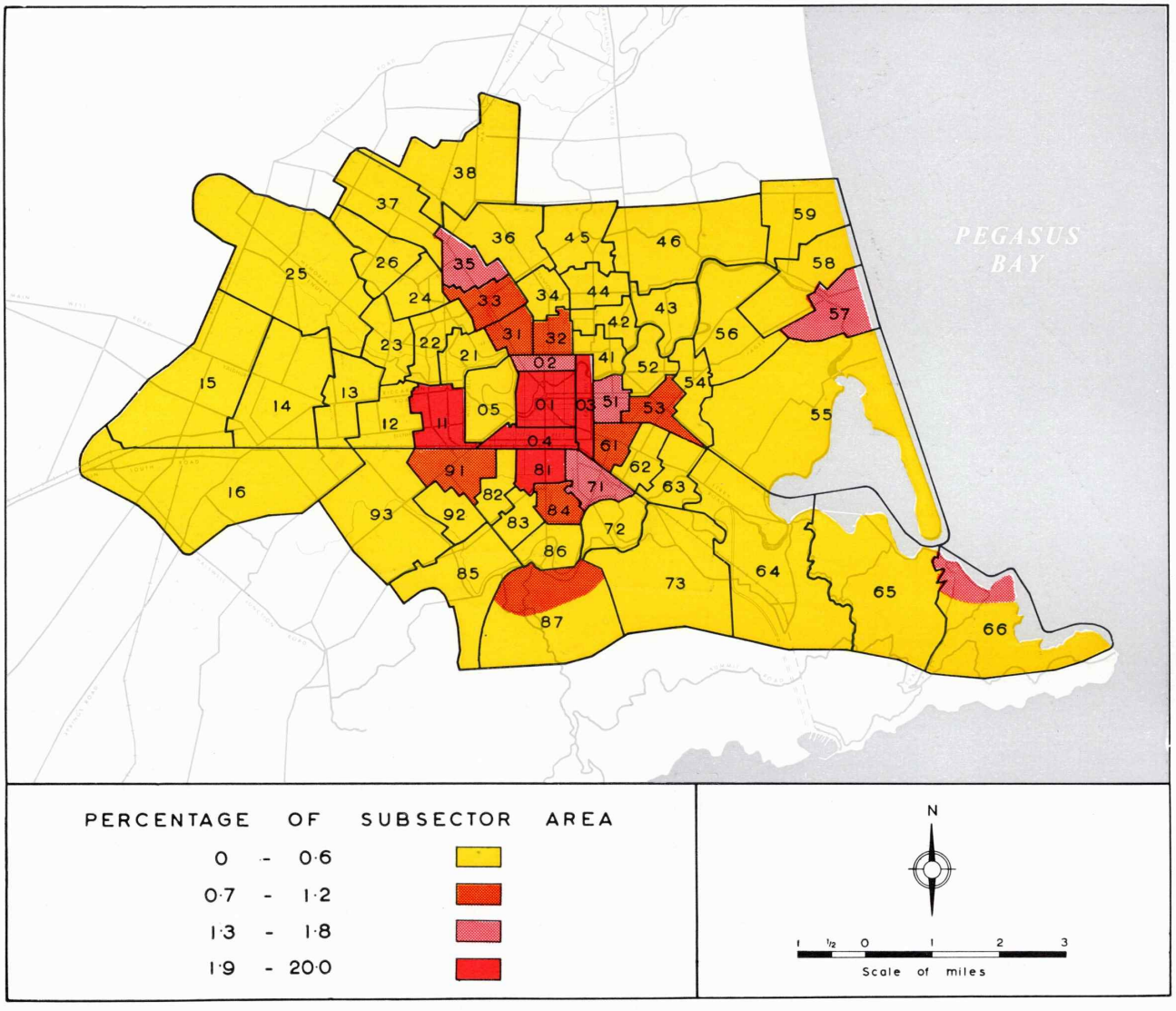


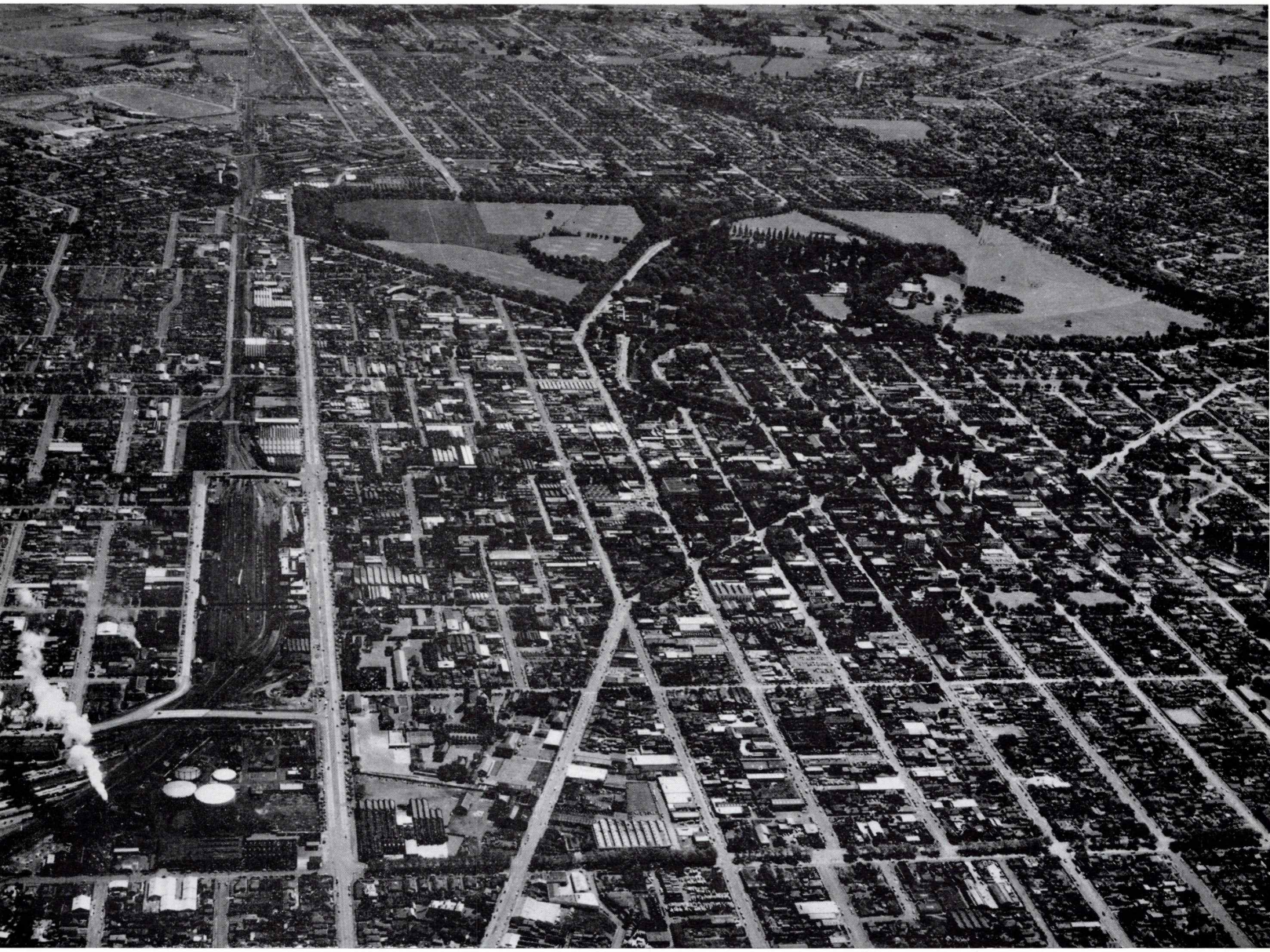
Fig. 14. COMMERCIAL LAND USE, 1956. Commercial activities do not use much land but are of great economic importance and concentrate in the central area. *See Table 43 in Appendix H for details by subsector.*

shopping or business trip which ranks as an important component of the total traffic volume.

INTENSITY OF USE

An examination of the distribution pattern of the various land use types within Christchurch provides information as to the broad patterns of traffic movement which might be expected to prevail in the city. However, the actual volume of traffic is likely to be more closely related to the intensity of urban land use which may be quite variable even for one specific type of function. For example, a block of residential apartment buildings has a larger potential for trip generation than an equivalent area of bungalow-type houses.

The intensity of land use can be measured in a number of ways. The area of floor space devoted to different urban functions is one such measure-



V. C. Browne Airview

Plate IX. CHRISTCHURCH FROM THE SOUTHEAST. The central retail and office area is prominent middle right: to the left is industry which extends along the parallel transport routes of the railway and Moorhouse Avenue (focus of photograph) and its extension (Blenheim Road) on the far side of Hagley Park. Riccarton Borough is top centre, Fendalton suburb top right.

ment, but unfortunately this data is not yet available either for the whole Christchurch area or for the complete range of functions to be found in the city. However, a more appropriate index of land use intensity in relation to traffic studies concerns the number of people living or working within some specified area. People, obviously, are the most important element in traffic movements, and the volume of traffic originating or terminating in any area will be related closely to the density of residential or employed population which is to be found in that area.

A gross index of the intensity of urban development, therefore, is the total number of persons residing in each area of the city. This index has

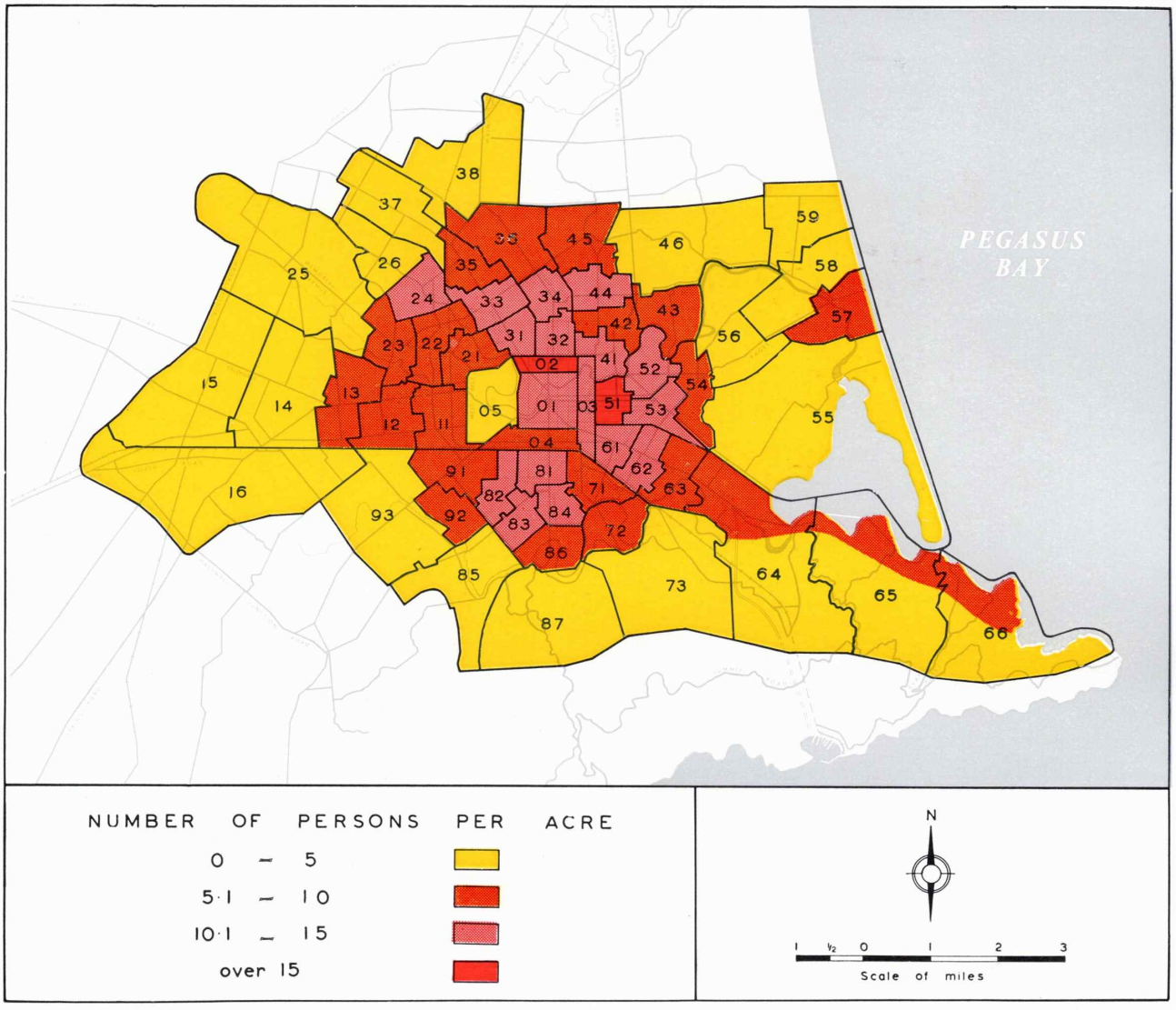


Fig. 15. POPULATION DENSITY, 1959: PERSONS RESIDENT PER ACRE. *See Table 44 in Appendix H for details by subsector.*

been mapped by subsectors in Christchurch (Fig. 15), and a comparison of this pattern with that of residential land use reveals some interesting points. The outer parts of the city are obviously areas of low population density. This appears to be particularly the case in the extreme northwest and on the hills to the south. In contrast, the central area especially along its northern parts appears to be of comparatively high population density, although residential land use is here only of intermediate importance in terms of the amount of land it occupies. The presence of numerous flats and boarding houses in the area helps to explain this apparent anomaly.

The pattern of population density also appears to be related to the age of urban development. The older parts of the city, including the central area and the adjacent suburbs to the north, east and south, show up as areas of high population density, while the more recently developed outer

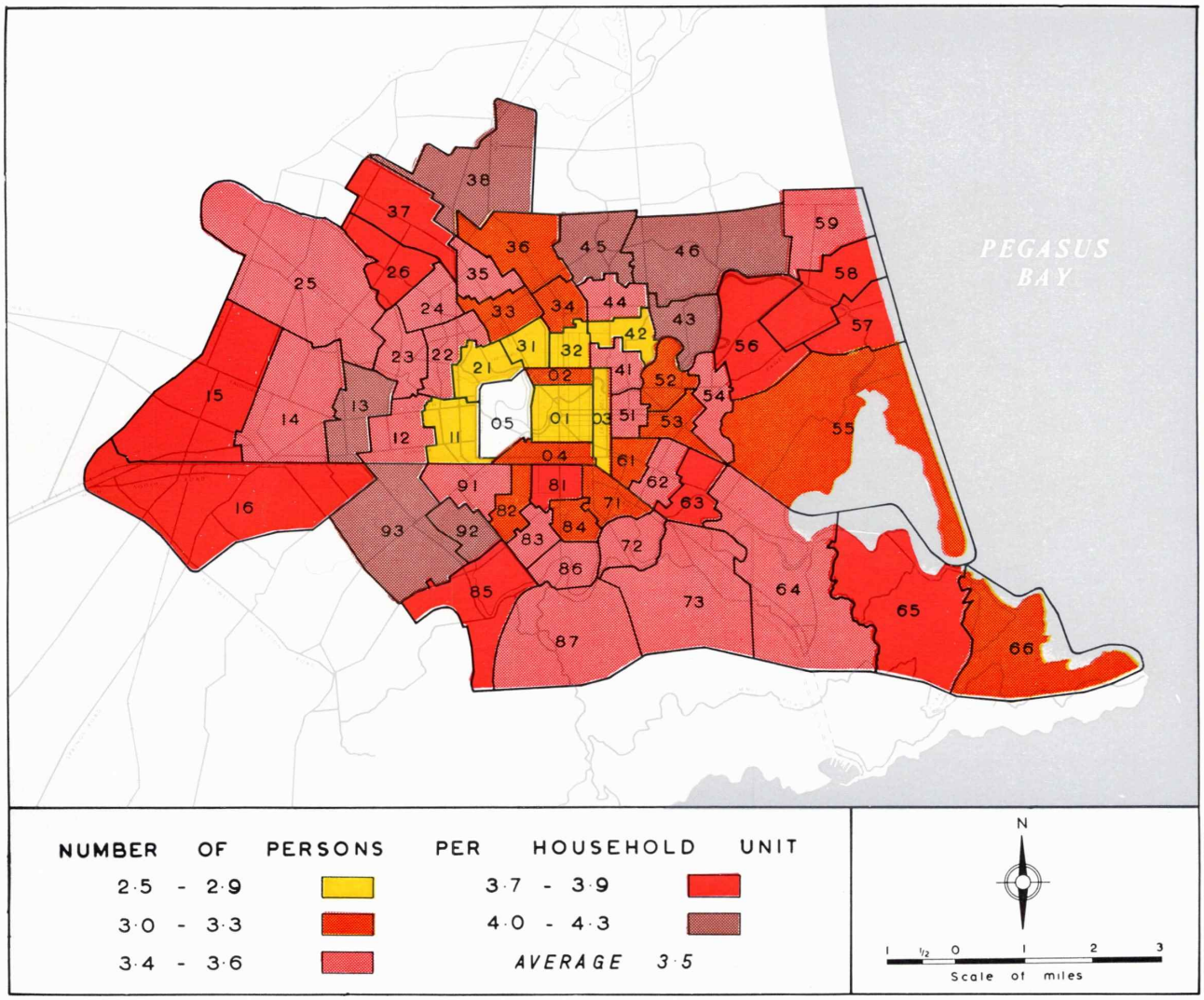


Fig. 16. POPULATION DENSITY, 1959: PERSONS PER HOUSEHOLD UNIT. *See Table 44 in Appendix H for details by subsector.*

zones of the city are typically of low density. In attempting to draw conclusions from the population density map about the expected volume of urban traffic, it is important to remember that the population index is weighted by the size of the subsector involved. A large suburban area characterised by a low population density may have as great a potential for total volume of traffic as a smaller downtown area in which the population density is perhaps two or three times higher.

It is possible to derive a more meaningful index of population density by eliminating much of the bias associated with variation in the areal size of the city subsectors. Since the subsectors were originally defined in such a way as to ensure that each one contained approximately 1,000 households[3] in 1959, the average number of persons per household unit in each subsector provides a

[3] A household unit is defined as a group of rooms or a single room, occupied or intended for occupancy as separate living quarters, by a family or other group of persons living together or by a person living alone.

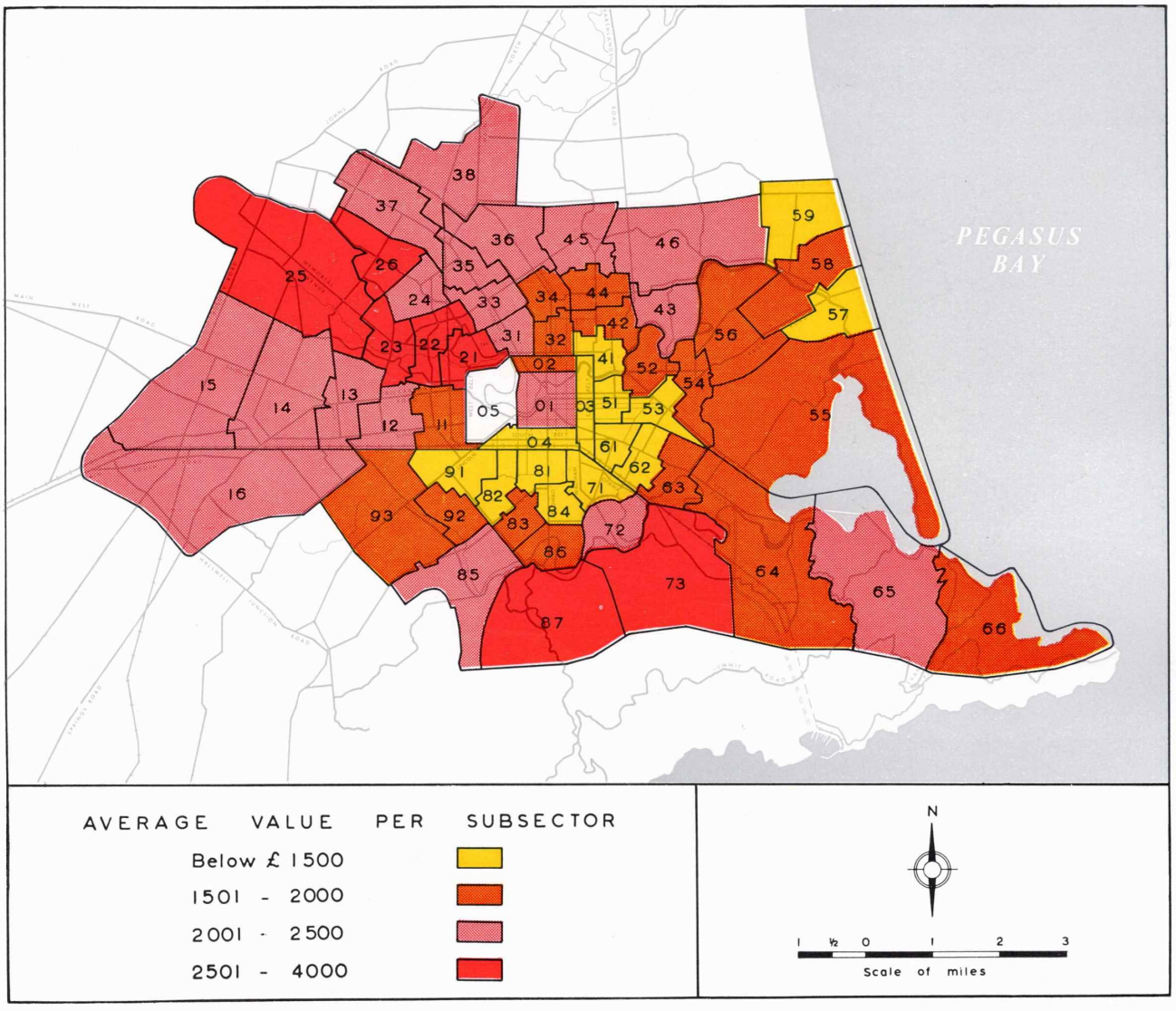


Fig. 17. VALUATION OF RESIDENTIAL IMPROVEMENTS, 1959. This pattern is in part indicative of variations in income and occupation. *See Table 44 in Appendix H for details by subsector.*

measure of density which is largely independent of areal size. The pattern associated with these density values appears to be a most significant one (Fig. 16). In terms of total population density per acre the central areas had comparatively high values, but on the new index they appear at the opposite end of the scale, with low densities in terms of persons per household unit. Conversely, the suburban areas, particularly in the southwest, northwest and northeast, now display much higher density figures. In the broader context of the traffic investigation, this pattern of density values is likely to be significant because the household unit or place of residence features as a very important origin and destination for urban traffic. The areas with high densities of persons per household will contribute a greater volume of traffic than areas of low density, assuming all

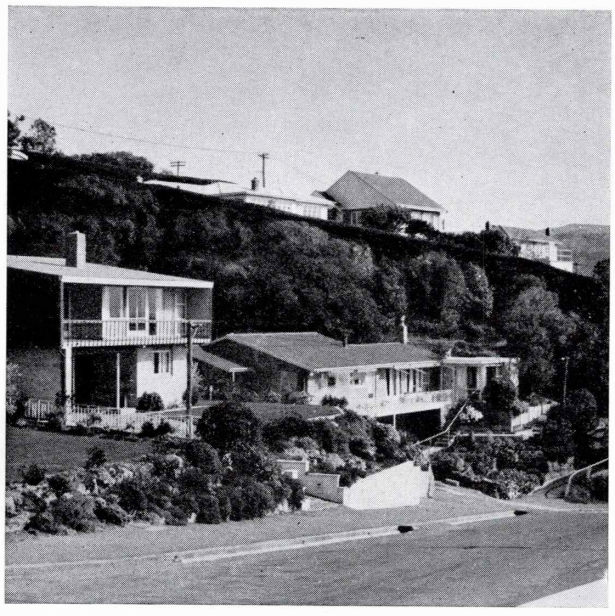


Plate X. '. . . . higher improvement values reflect higher levels of income . . . .'

other factors to be equal. The latter assumption is of course unrealistic and it is probable that the potential of any residential area, in terms of traffic generation, will be influenced by many other factors including the level of income, the occupational status of the population, and the employment opportunities existing near at hand.

It is realistic to assume for example, that the level of motor vehicle ownership per capita and the corresponding reliance upon private means of transport are likely to vary in association with income. Furthermore, the dominant type of occupation for any subsector is likely to be reflected in a characteristic pattern of traffic movement; for instance, the areas of professional or managerial workers will undoubtedly contribute more trips, of the journey to work type, to the centre of the city than will areas occupied predominantly by industrial employees. These factors of income and occupation are indexed in part by the value of improvements associated with each residential property. Presumably, the higher improvement values reflect higher levels of income which in turn, are most probably associated with professional and managerial occupations. Therefore, it might be anticipated that the residential areas in Christchurch which are characterised by high improvement values, notably the Cashmere district (subsectors 73 and 87) on the hills to the south and Fendalton-Burnside (subsectors 21 to 26) in the northwest (Fig. 17), will contribute comparatively more workers to the city centre than will the lower valued areas and it may be assumed that people travelling out of these high value areas will be more likely to drive cars than rely on other forms of transport.

EMPLOYMENT

Up to this point, the intensity of land use has been discussed in terms of the density of population residing within a specified area or of the various household units within that area. In the study of urban traffic these residential densities are critical to the extent that they are closely related to the pattern and volume of movement. But there are other forces at work that generate traffic within the city. The journey to and from work for example, will rank as a very important traffic component for any subsector and will partly depend on the employment opportunities that are present. For this reason, it is pertinent to consider briefly, the distribution of employment opportunity within the city (Fig. 18).

The total employed population in the Christchurch area in 1959 amounted to nearly 70,000 persons. By virtue of its undisputed role as the hub around which most of the city's economic life revolves, the Central Traffic District—largely the central business district and associated parking areas—contained by far the greatest single proportion, 42 per cent, of the employed population. This central concentration of employment opportunity extends beyond the Central Traffic District to the railway line in the south, and east-west along it. To the west of Hagley Park there are two smaller employment peaks associated with the Riccarton Borough and the Sockburn-Hornby area. Even when the total employment figure is broken down into its components the pattern remains much the same. For example, the level of industrial employment in the Central Traffic District is above the other subsectors, although, as we have already seen, the subsectors along the

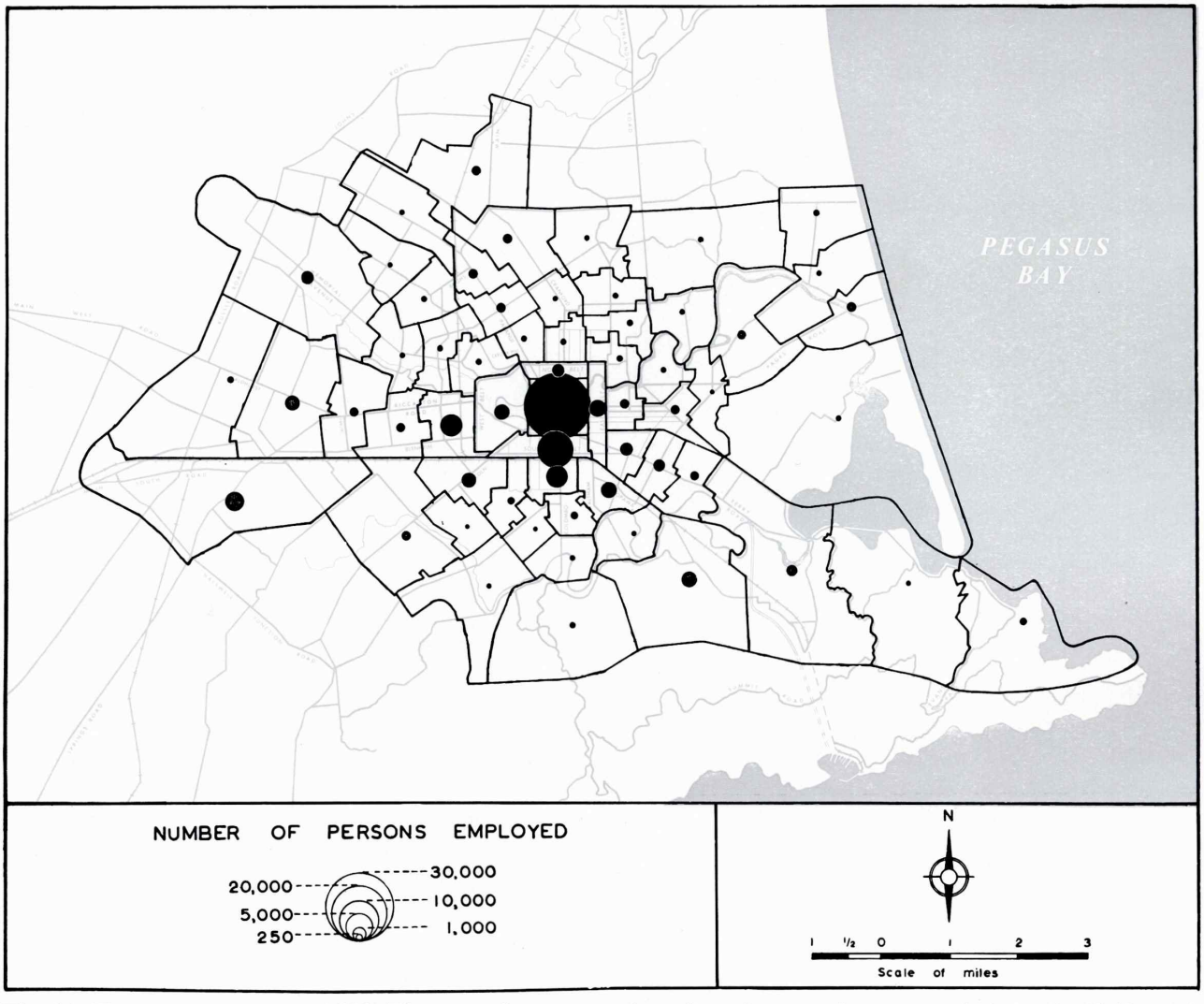


Fig. 18. TOTAL EMPLOYMENT, 1959. The central concentration of employment is at once obvious. *See Table 44 in Appendix H for details by subsector.*

main trunk railway are the more important ones in terms of area devoted to industry. Admittedly, these subsectors do show up as secondary concentrations of industrial employment (Fig. 19).

The predominance of the city core as a place of employment is even more pronounced with respect to commercial employment in shopping centres[4] (Fig. 20). As much as 77 per cent of the labour force engaged in shopping centres is to be found in the Central Traffic District, while another 11 per cent is employed in the adjacent subsectors. This distribution pattern of commercial employment emphasises the hierarchical structure of commercial activity within the city. Below the city centre are the important secondary commercial centres of Riccarton, Papanui, New Brighton, Sumner, Sydenham and Addington. In each of these areas commercial employment is in excess of 100 persons. The next tier in the commercial hierarchy is represented by numerous clusters of stores, such as Upper Ric-

[4] A shopping centre is defined as having a minimum of six shops.

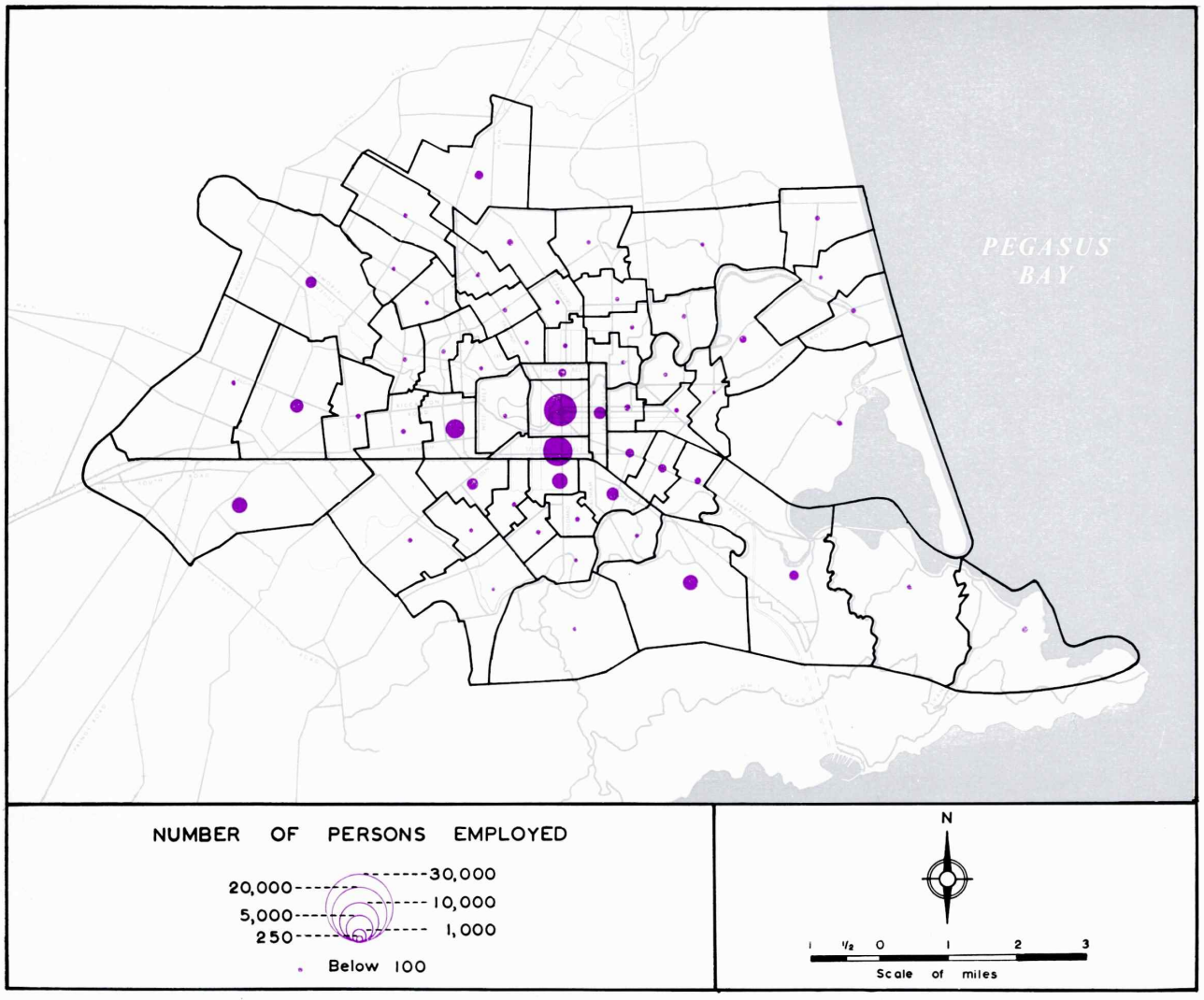


Fig. 19. INDUSTRIAL EMPLOYMENT, 1959. *See Table 44 in Appendix H for details by subsector.*

carton or St. Albans, which employ between 50 and 100 persons. At the lowest level and most numerous is the individual store or small cluster of stores employing from one to 50 persons.

These commercial centres are likely to have dual importance in terms of traffic generation. They obviously provide employment opportunities for a significant proportion of the city's labour force and as a result they will generate a considerable volume of traffic as people move daily to and from these places of employment. At the same time, these commercial centres provide goods and services which are demanded by the whole urban population; therefore the traffic to and from these employment centres will be boosted by the movement of consumers on shopping and business trips.

SUMMARY

The preceding discussion of the distribution and intensity of land uses within Christchurch provides a background against which the urban traffic

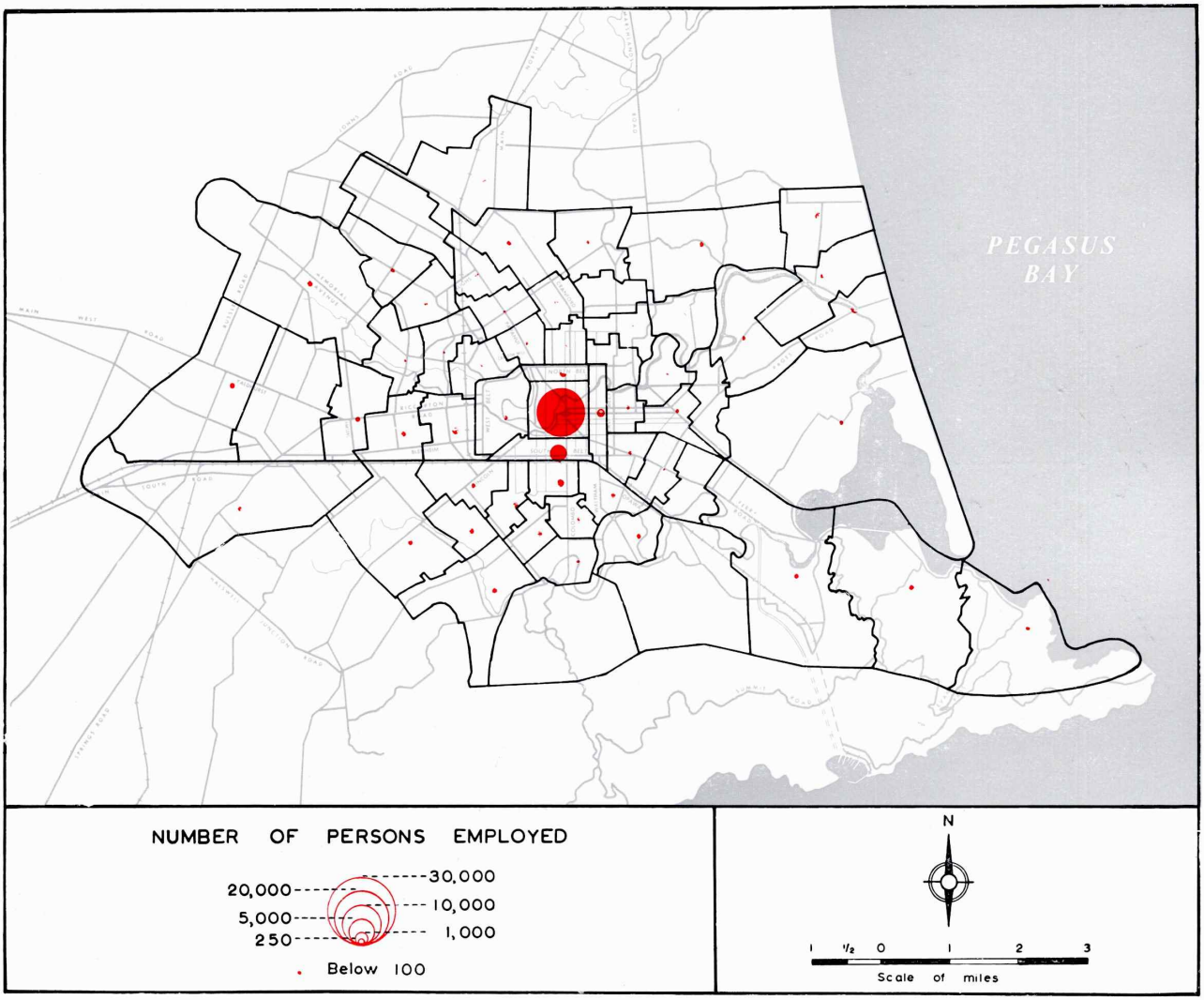


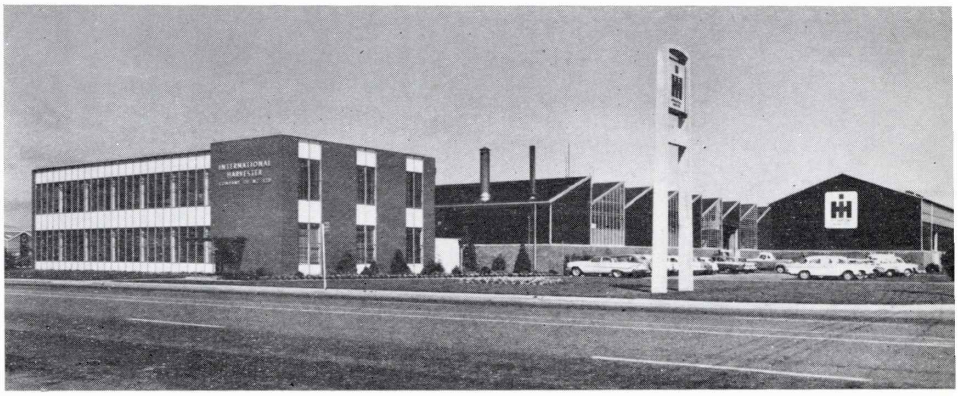
Fig. 20. Commercial employment, 1959. *See Table 44 in Appendix H for details by subsector.*

flows can be set. In broad perspective, there appear to be at work within the urban area two major forces which will contribute in large part to the total volume of urban traffic. The first of these forces is the very strong attraction of the central business district as a centre of employment opportunity. This attraction stems from the district's undisputed position as the major commercial and industrial centre of the city and as a result it will undoubtedly rank as the major focus of internal urban traffic. The second major force is represented by the tendency for people to live away from the centre of the city and in the outlying suburban districts. These predominantly residential districts act as the source areas for the employees required in the central business district. The interaction between the suburbs and the centre of the city is likely to produce by far the greatest amount of traffic flow.

At the same time it should be stressed that the pull of the central district is likely to be counteracted in part by the influence associated with

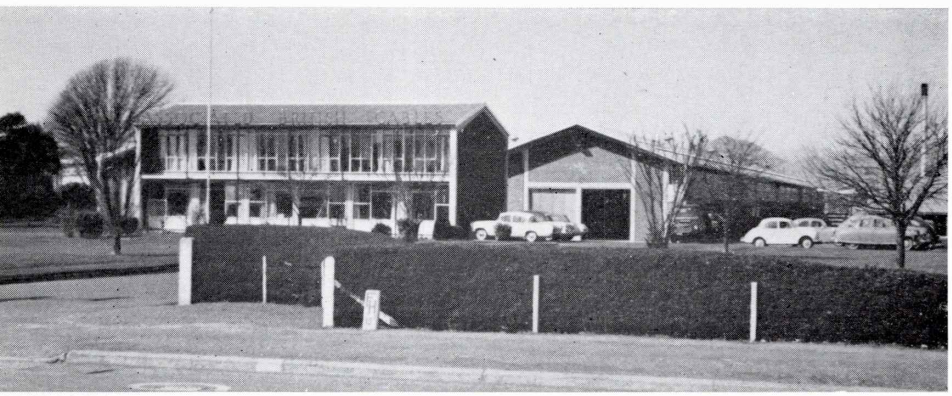
Plate XI

Industrial Development



Courtesy of International Harvester Co. of N.Z. Ltd.

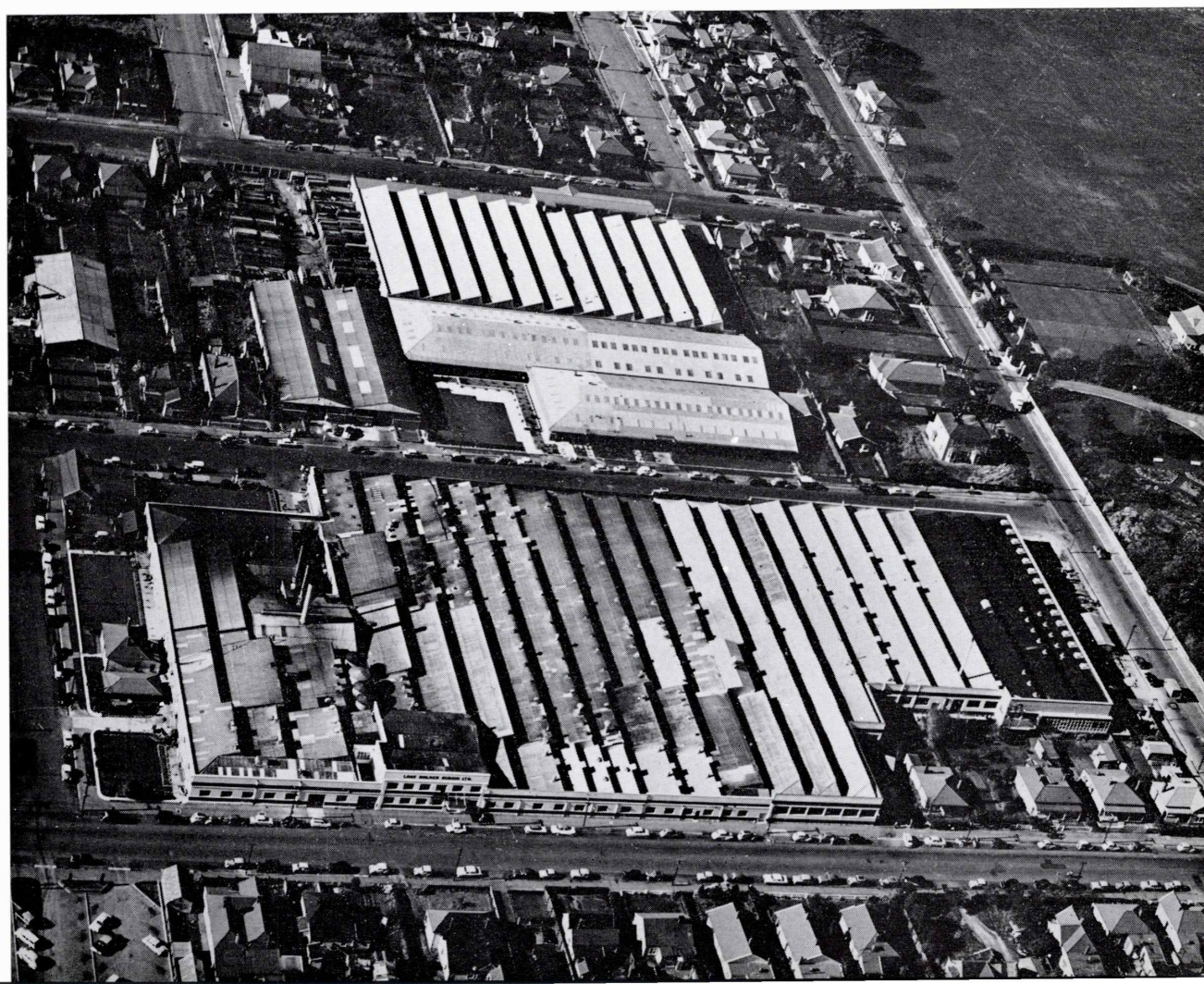
Modern space-demanding factory near road and railway

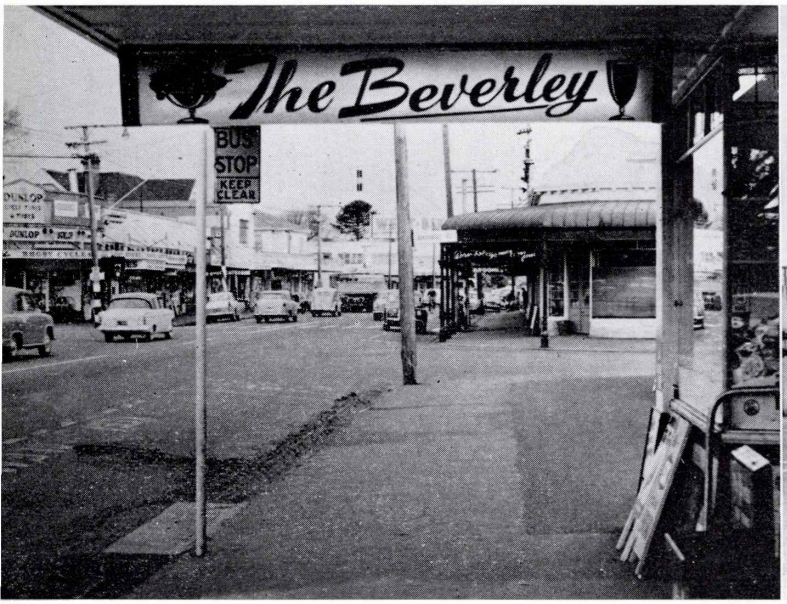


Suburban garden factory

Expansion of labour-demanding industry amidst old houses of inner city

Courtesy of Lane Walker Rudkin Ltd.





Linear type

Cross-roads type

Plate XII. Suburban shopping centres

secondary commercial and industrial centres of which Riccarton, Sydenham, New Brighton and Sumner are the most important. These centres appear as additional focal points for urban traffic movements, and serve to disrupt the dominant pattern of movement between the suburbs and the city centre.

This chapter has presented data based on surveys of 1956-1959 about the Christchurch area and shows something of an orderly pattern of growth not only in an historical sense but also in terms of the functions which are represented by the present land use. It has been suggested that the location and intensity of urban land use affects the origin, flow and destination of traffic, and that, in turn, traffic affects the type of land use in an area. Commercial activities which require a high degree of accessibility for many people are located in the centre of the city; industry seeks land in relation partly to transport routes and partly to population; and people live in areas that have something of a symmetrical arrangement around the central business district and near employment and services. The rational arrangement of land use reflects the mutual interaction of urban functions and travel.

CHAPTER THREE

Travel and Traffic 1959

THE MOVEMENTS of people and vehicles form an integral part of urban life. Whereas the movements of an individual are often irrational, and are subject to the whims of personal wants and needs, urban dwellers as a whole observe a certain regularity and orderliness in their daily travel, and this is reflected in the times and purposes of their movements to home, to work, to shops, and to various other destinations. Regularity of movement is also apparent in the movement of trade vehicles and other carriers of goods.

A survey of the total movements of all people and vehicles within a city involves the gathering of data on traffic volumes, directions of flow, times of flow, modes of travel and purposes of travel. In order to obtain this information, it is necessary to account for all movements made by individuals, whether by private vehicles, mass transportation media, or any other way.

To provide a basis for analysing the patterns of movement, Christchurch and its environs were divided into a number of areas. Initially a division was made between the major built-up area on the one hand (the Internal Area) and the remainder of the South Island (the External Area) on the other. The Internal Area was divided into 10 major *sectors*, based mainly upon radial roads, and these were further subdivided into 59 *subsectors*. The External Area was divided into 46 *localities*, 14 of which immediately surround the Internal Area.

The boundary between the *internal subsectors* and *external localities* was labelled the External Cordon Line. Within the Internal Area another boundary —the Internal Cordon Line—was drawn about subsector 01, and this subsector was designated the Central Traffic District.[1] Another boundary —the Belt[2] or Intermediate Cordon Line— was established between the Central Traffic District and the External Cordon Line. A fourth line—the Transverse Screen Line—was drawn right across the Internal Area from east to west.

THE SURVEYS

The surveys aimed at accounting for movements within the Internal Area and for external movements which either originated or terminated within the Internal Area or passed right through it. The various surveys were grouped according to the type of information obtained.

The first group of surveys—the travel surveys— sought information regarding the origin, destination, mode, purpose, and times of personal travel for all trips, a trip being defined as a journey of half a mile or more and a movement from one subsector to another. This information was collected by means of:

(i) a 50 per cent sample of drivers crossing the External Cordon Line (the External Cordon Interview Survey);

(ii) reply-paid questionnaire postcards issued to travellers crossing the External Cordon Line in buses and local trains (the Bus and Train Passenger Questionnaire Survey);

(iii) a five per cent random sample of all households in the Internal Area (the Home Questionnaire Survey which was personally distributed and collected); and

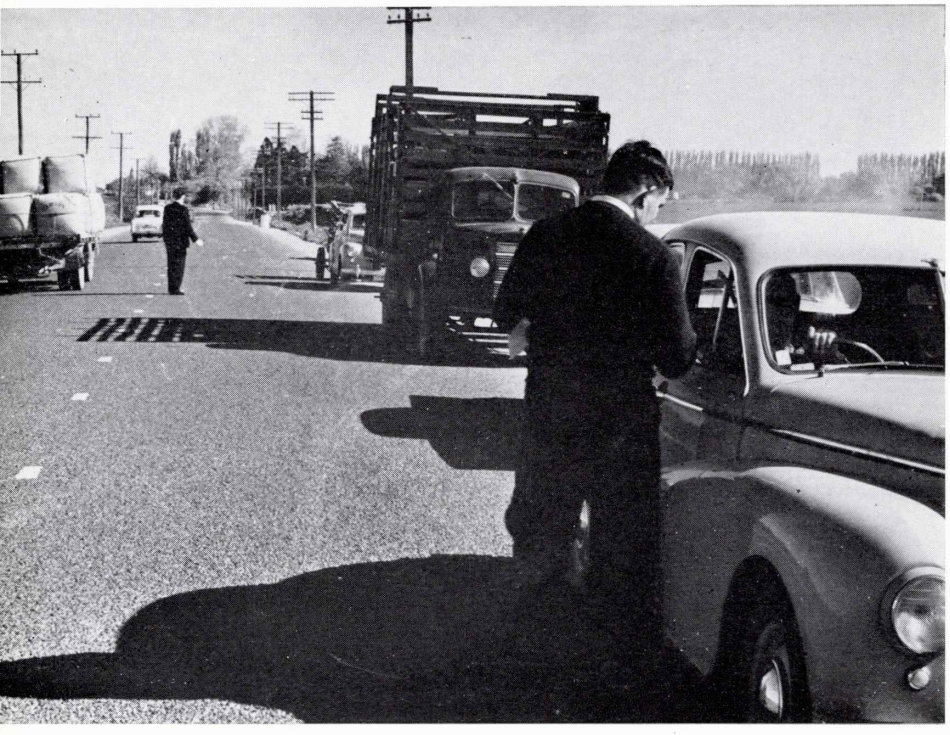
(iv) the issue of log sheets to a 20 per cent sample of taxis and a 12½ per cent sample of trade vehicles operating from the Internal Area (the Taxi and Trade Vehicle Surveys).

[1] The Central Traffic District was defined as comprising a large part of the central business district and associated parking area.
[2] The term 'Belt' or 'Belts' refers to Deans, Harper, Bealey, Fitzgerald and Moorhouse Avenues; the Belt Cordon Line lies immediately outside the Belts. See Appendix C for details of the various survey lines.

Plate XIII

Counting People

Taxi Survey

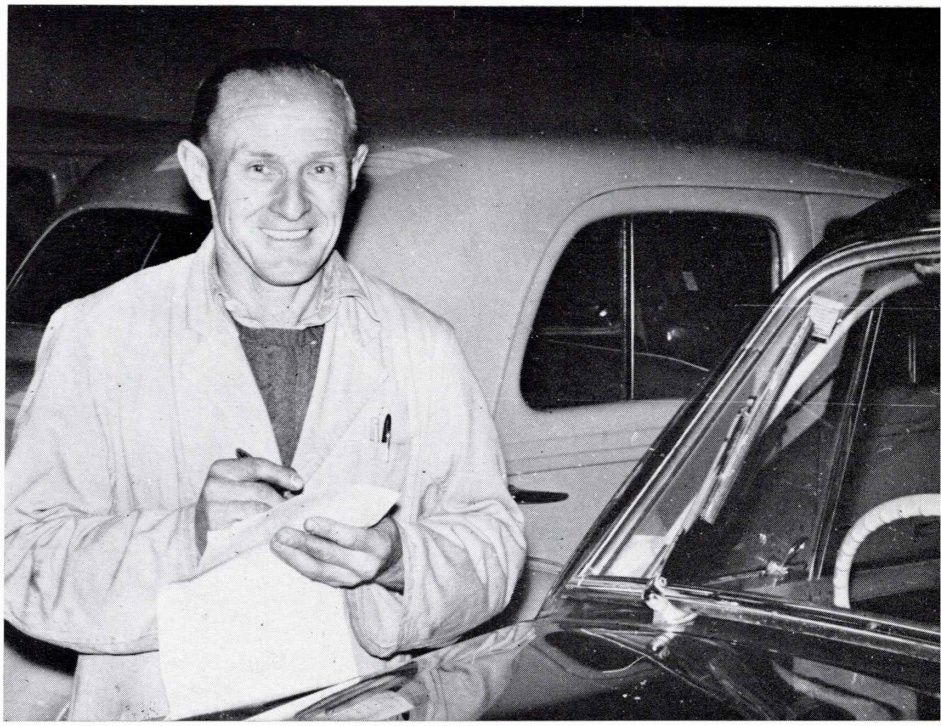


External Cordon Interview

Home Questionnaire Survey

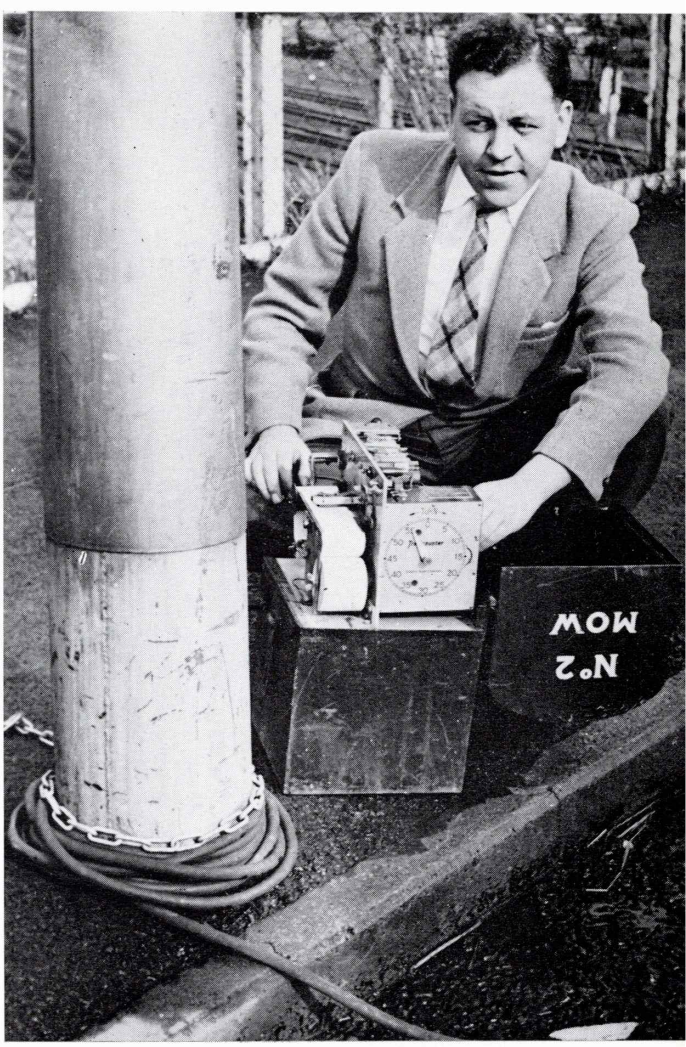
Plate XIV

Counting Vehicles



Parking Survey

Manual Count



Mechanical Count

The second group of surveys—the traffic surveys —counted vehicles or people according to:

(i) the number and type of vehicles and passengers therein crossing the External Cordon Line;

(ii) the number and type of motor vehicles, passengers, pedal cyclists and pedestrians crossing the Internal Cordon Line;[3]

(iii) a numerical machine count of vehicles crossing the Belt Cordon Line; and

(iv) the number and type of vehicles traversing a line drawn through the city from east to west so that all vehicles moving north and south would have to cross it (the Transverse Screen Line)[3].

In addition to the checks on movement of vehicles and people, a survey was made of stationary vehicles in the Central Traffic District between 6.30 a.m. and 6.30 p.m. and this was aimed at assessing the demand on available parking space within the Central Traffic District. The survey was done by means of hourly checks on the number, type and location of all stationary vehicles parked on and off the street within the District.

As some of the surveys were carried out on a sample basis, the data obtained only represented a proportion of the total traffic or travel covered by a particular survey. To make the sample representative of all traffic, expansion factors were used. It was necessary to multiply the results of those surveys that were made on a sample basis by an expansion factor so that the number of trips recorded in them equated, as nearly as possible, to the total number of trips that were actually made by the whole population. Theoretically this could be done by multiplying the results, say, of a survey that was done on a five per cent sample by 20, or one that was done on a $12\frac{1}{2}$ per cent sample by eight and so on. However it was also necessary to make an estimate of how accurately or how fully the questions asked in the surveys had been answered. To do this the figures obtained after multiplying by the theoretical expansion factor were compared with the appropriate traffic counts made at such places as the External Cordon Line and the Transverse Screen Line. When this was done the theoretical expansion factor was amended so that the results of the surveys, when multiplied by amended expansion factors, accounted more nearly for the traffic that was actually on the roads.

Comparison of the expanded travel survey data —after amendment—with results obtained from the screen and cordon counts of total traffic gives a fairly high correspondence (Table 2), showing that deductions made from the surveys will reflect and account for the major patterns of movement

[3] These observations were supplemented by machine counts and Train and Bus Passenger load data.

TABLE 2

COMPARISON OF EXPANDED TRAVEL SURVEY DATA TO SCREEN AND CORDON TRAFFIC COUNTS*, FOR 12 HOUR PERIOD: 1959

LOCATION	CARS			TRADE VEHICLES			TOTALS		
	Travel Survey †	*Traffic Count*	%	*Travel Survey* †	*Traffic Count*	%	*Travel Survey* †	*Traffic Count*	%
Transverse Screen Line ..	27,135	30,689	$88\frac{1}{2}$	10,437	11,709	89	37,572	42,398	$88\frac{1}{2}$
Internal Cordon Line ..	71,318	80,530	$88\frac{1}{2}$	19,956	20,870	$95\frac{1}{2}$	91,274	101,400	90
Belt Cordon Line ..	86,002	92,623	93	25,556	27,305	$93\frac{1}{2}$	111,558	119,928	93
External Cordon Line	13,994	13,994	100	5,529	5,529	100	19,523	19,523	100

* Passenger cars (including taxis) and trade vehicles only.
† After adjustment of expansion factors as a result of the Transverse Screen Line check.

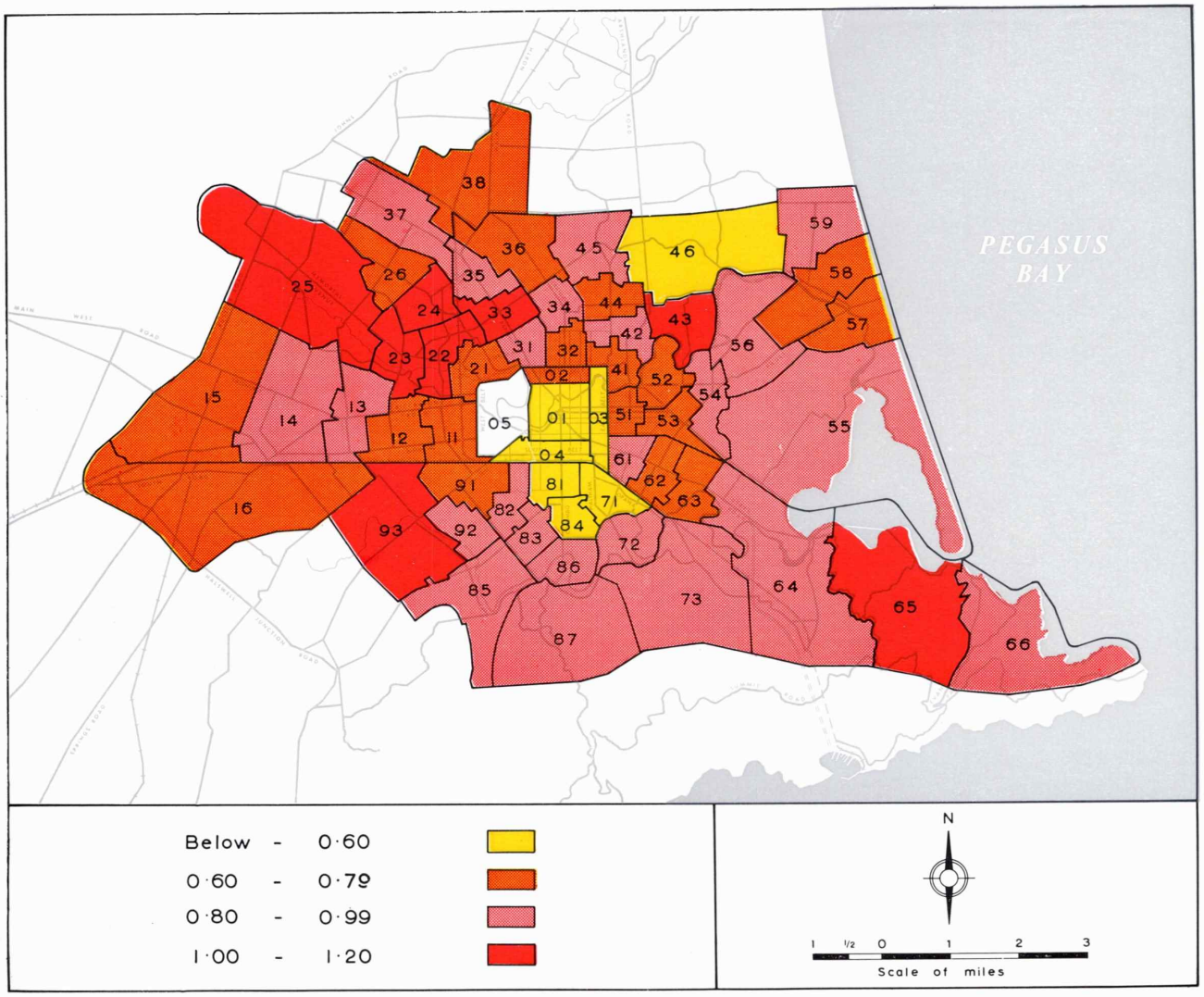


Fig. 21. CAR OWNERSHIP, 1959: CARS PER HOUSEHOLD UNIT. The average number of cars per household in 1959 is 0.81. *See Table 44 in Appendix H for details by subsector.*

within the city. These results indicate a reasonable level of accuracy and reliability of data and thereby show that the data collected provides a sound basis for determining the average daily patterns of movement in Christchurch. Further description and explanation of the surveys is available in Appendices C and D.

VEHICLE RATIOS

It is also necessary to consider vehicle ownership. In 1959 the population of Christchurch was about 200,000 and there were nearly 67,000 registered motor vehicles. The number of persons per vehicle was 3.25 (Table 49 in Appendix H). Most of the registered motor vehicles were cars (80 per cent), and, on average, there were four persons per car. Of the remaining vehicles, 12 per cent were trade vehicles, and eight per cent were motor cycles, power cycles, and miscellaneous registered vehicles.

Another measure of car ownership is in terms of cars per household and for Christchurch an index of 0.81 cars per household is the average for 1959. The range of car ownership varies however from as little as three *households per car* in some inner subsectors, to over one *car per household* in some northwestern and southeastern subsectors (Fig. 21).

The subsectors surrounding the Central Traffic District stand out as areas of low density owner-

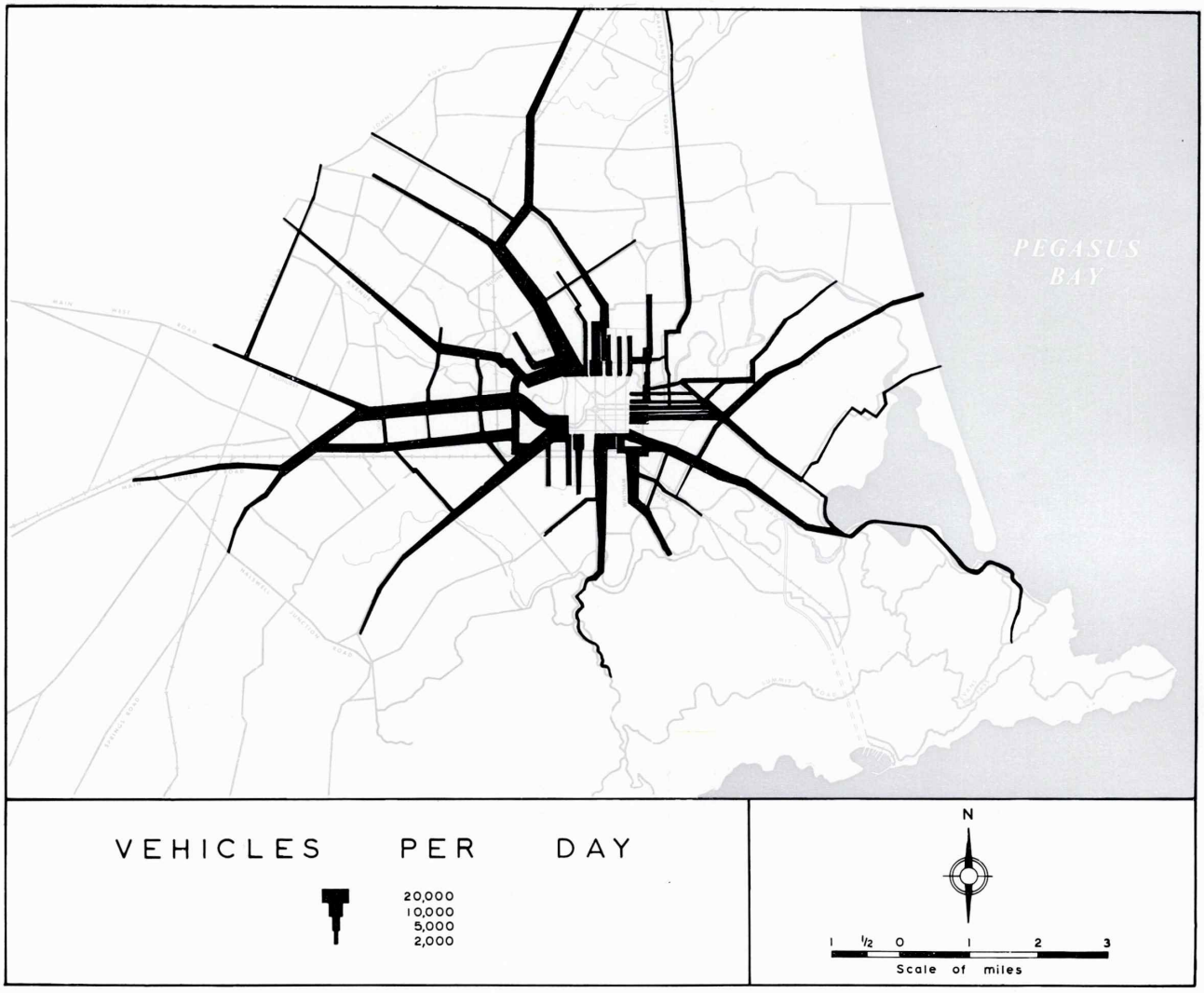


Fig. 22. Traffic flows in Christchurch, 1959. Traffic covers machine counts of private cars, taxis and trade vehicles in 24 hours on an average weekday. Buses and all types of cycles are excluded. This map is a generalisation of the data by streets shown on Figure 65.

ship. There is in fact a belt completely surrounding the District for about two miles in all directions in which car ownership is generally below average and this belt spreads generally northeastwards and westwards. This belt of low to average car ownership is succeeded almost immediately in the northwest and south by two zones of above average ownership. The southern and southeastern areas form a crescent (following the hill zone) in which the index is 0.90 or 1.00 cars per household. This contrasts with the northwestern area where the ownership index reaches its maximum and a solid block of subsectors with indices greater than 1.00 occurs. The interstitial areas, for example in the southwest and northeast, have a rather varied pattern, with the southwest generally being below average, and the northeast slightly above average.

Within the Internal Area vehicle utilisation is reasonably high with an overall average of 3.35 trips per motor vehicle per day. A breakdown of this traffic shows that trade vehicles—with 5.35 trips per day—are used far more frequently than cars—2.26 trips per day. These figures show clearly that there is substantial movement of vehicles about the city, with cars being used for more than just one round trip each day (such as from home to work to home), and trade vehicles averaging almost three round trips (or delivery trips) per day.

WEEKDAY TRAVEL

Approximately 355,000 person trips[4] were made between 6.30 a.m. and 6.30 p.m. on an average weekday of 1959 and, after adjustment, this gives a total for the 24 hour period of about 490,000. Of these, 90 per cent were made within the Internal Area and 10 per cent crossed the External Cordon Line.

During the 12 hour period vehicles made approximately 163,000 trips and, after adjustment, this gives a 24 hour total of 220,000 trips. Of these, 88 per cent were made within the Internal Area and 12 per cent crossed the External Cordon Line. The pattern of vehicular trips as obtained in the traffic surveys is seen on the map of 1959 traffic (Fig. 22).

[4] A person trip is defined as a single trip from one origin to one destination by a person using any mode of transport. A vehicle trip is defined as a one way journey by car, taxi or trade vehicle from one origin to one destination. In both cases a trip represents a journey of half a mile or more and involves a movement from one subsector to another.

Plate XV. '. . . . car ownership is high but many cars are old . . . .'

MODE OF TRAVEL

VEHICLE TYPES

Under present economic and technological conditions the motor car is almost ubiquitous and represents the principal mover of persons in nearly all major cities of the western world. Christchurch is no exception to this general rule and, in terms of vehicle trips, cars outnumber trade vehicles by almost three to one (Table 3). The traffic pattern is complicated slightly by trade vehicles being used throughout the day and by omnibuses. The latter become significant in terms of numbers and space-usage at the peak hours when many converge on the city centre. Trade

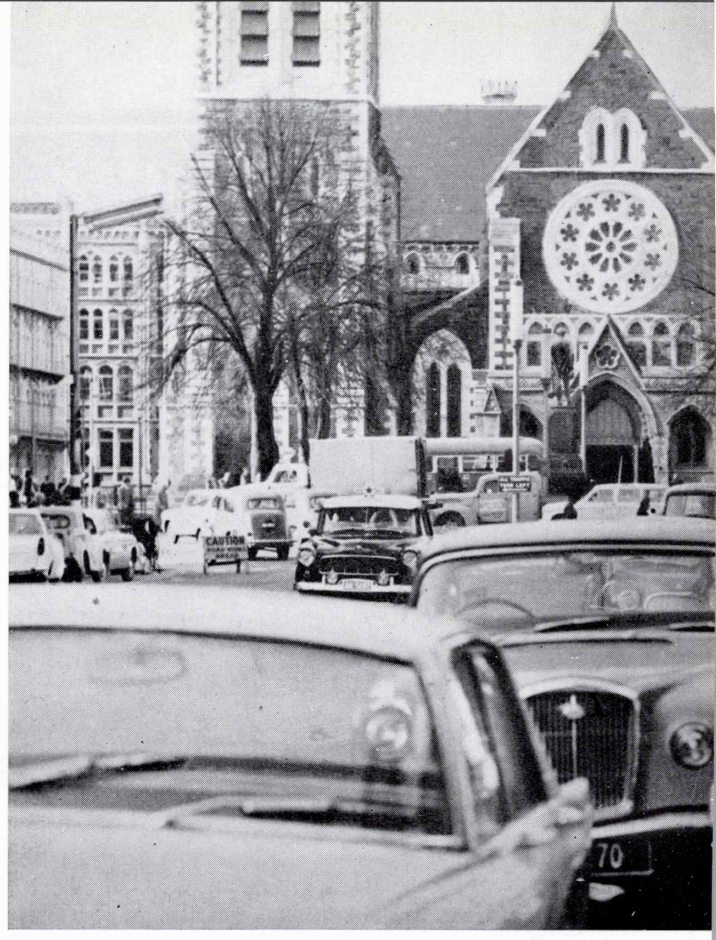
TABLE 3

VEHICLE TRIPS, BY MODE AND TYPE OF MOVEMENT FOR 12 HOUR PERIOD: 1959

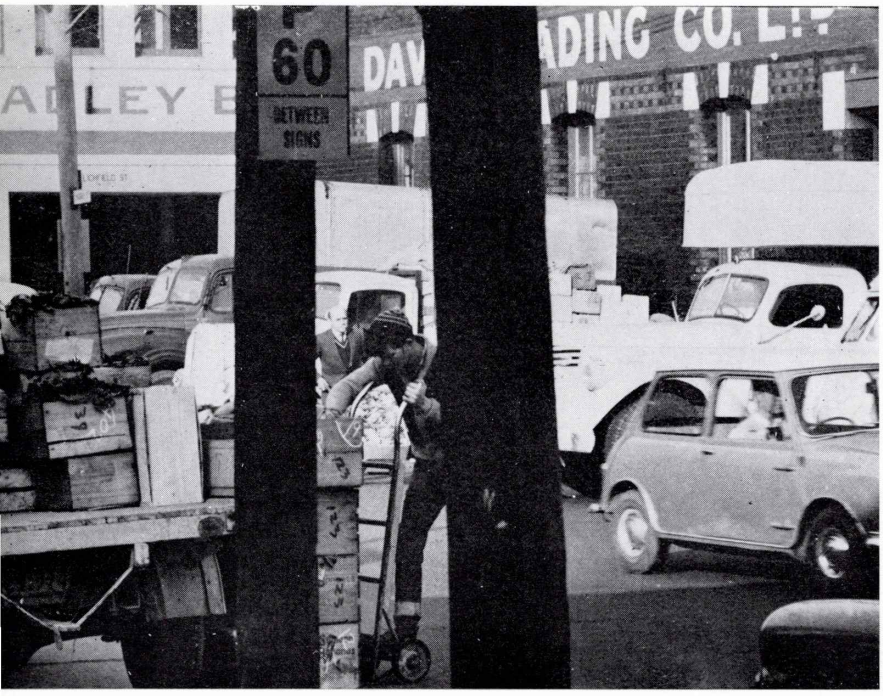
TYPE OF MOVEMENT	NUMBER OF VEHICLE TRIPS		TOTAL VEHICLE TRIPS	PERCENTAGE OF VEHICLE TRIPS	
	Cars	*Trade Vehicles*		*Cars*	*Trade Vehicles*
Within Internal Area . .	106,334	37,252	143,586	74	26
Between External and Internal	13,660	5,329	18,989	72	28
Through Traffic	167	100	267	62.5	37.5
TOTAL	120,161	42,681	162,842	73.7	26.3

Plate XVI

Transport and Trade



'. . . . the car is the principal mover of people . . .'



'. . . . a preponderance of heavy trade vehicles . .'

'. . . . the number of cyclists about the city . . . .'

vehicles can be divided into light vehicles, for example vans and utilities, and heavy vehicles. Although the former are more manoeuvrable in the city traffic, there is a preponderance of heavy vehicles on the road. These include most delivery trucks, especially those in the fleets used by removal companies. Heavy vehicles are also used for the transport of stock to the Addington saleyards and the city abattoirs. The most significant use of heavy trade vehicles is found in association with the railway yards and the inner city industrial area (subsectors 04 and 81). Light trade vehicles are primarily used for retail delivery from stores and service industries, for example dry cleaners.

Trade vehicle trips are distinct from car trips by virtue of their lack of 'personal' motive. For the most part they are used for trade purposes and they carry few passengers. Their time pattern also varies from that of cars. Cars on the other hand are far more significant in total travel; they represent 74 per cent of the total vehicular movement in Christchurch (excluding buses), and clearly dominate both internal and external movements.

PERSONAL TRAVEL

The casual observer of traffic in Christchurch invariably remarks on the number of cyclists to be seen about the city. Although not the dominant mode of travel, cycles are sufficiently numerous to detract from the overall importance of motor traffic, for they provide 32 per cent of the total person trips undertaken on an average weekday (Table 4). Motor cars and taxis provide the principal modes for personal travel and together they exceed cycles (in terms of total person trips) by nine per cent. Forms of mass transportation (buses and trains) carried only 17 per cent of all person trips; transport by individual means is therefore very high.

Each travel mode has a distinctive pattern of movement and this pattern becomes more significant when compared to the characteristics of each subsector or groups of subsectors generating the movement. Particular patterns reflect changes in income levels, increases or decreases in the ratio

TABLE 4

PERSON TRIPS FOR THE INTERNAL AREA*, BY MODE FOR 12 HOUR PERIOD : 1959

Mode	*Number of Person Trips*		*Percentage of Total Person Trips*	
Passenger Car Drivers	99,053	130,275	31	41
Car Passengers	31,222		10	
Cyclists		102,656		32
Bus Passengers		53,164		17
Pedestrians		26,107		8
Other Modes†		5,644		2

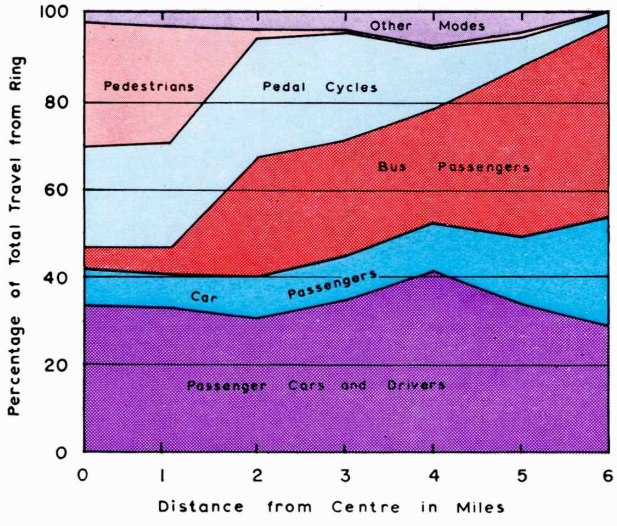
* This excludes trips from the External Area.
† Trade vehicle, taxi and train.

of cars to households, and the presence of a primarily tentacular system rather than network of mass transportation routes; and of course the intensity of use of any mode varies with the length of trips.

EFFECT OF DISTANCE

The general effect of distance on the mode of travel can be seen in Figure 23. For short distances walking and cycling appear as the dominant modes, but their importance relative to other

Fig. 23. DISTANCE AND THE MODE OF TRAVEL TO THE CENTRAL TRAFFIC DISTRICT, 1959. *See Table 9.*



forms of transport decreases as distance increases. Distance affects cycle travel much less than pedestrian trips however; whereas the latter virtually disappear from trips over two miles, cycles are still evident in total trips up to a distance of four to five miles from the city centre.

Movements by car and by mass transportation show features that are the reverse of pedestrian traffic. The importance of car and bus travel increases directly with distance from the centre of the city. Motorised traffic in fact accounts for nearly all trips from areas greater than five miles from the centre. One interesting feature of motorised traffic movement is the increase of car passengers as distance from the city core increases. A corresponding decrease occurs in the number of drivers of private vehicles. This tendency may be a product of the desire to minimise costs of travel by arranging with friends or neighbours to 'pool' vehicles and use them on a roster. Besides economising on fuel and depreciation costs, such a move minimises the parking problem for all concerned. Group travel of this type appears strongest beyond a four-mile radius from the centre.

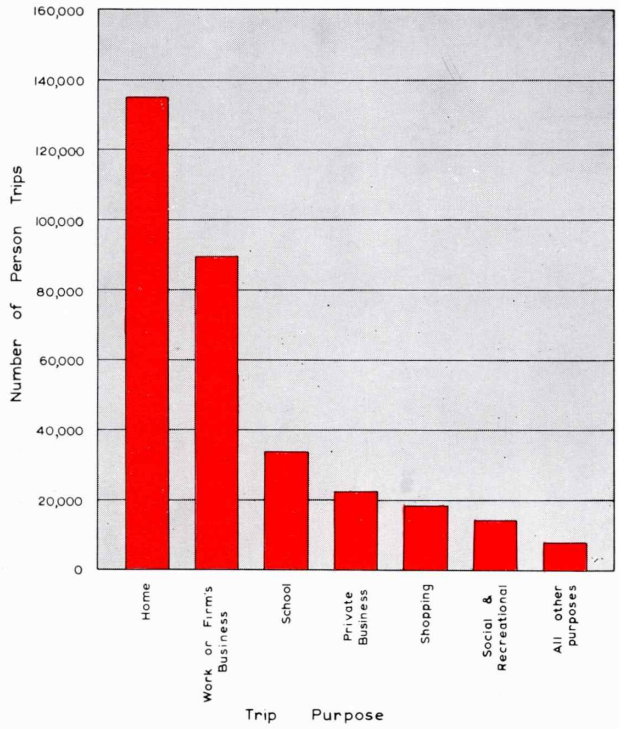


Fig. 24. PURPOSE OF TRIPS IN THE INTERNAL AREA, 1959. *See Table 5.*

PURPOSE OF TRAVEL

Each person or vehicle trip takes place for some definite purpose or combination of purposes. The range of purposes is influenced by the social customs operating within a city, particularly those relating to work, recreation and home life. For the bulk of the city population, the purposes of travel change as the day progresses; whereas in the morning the principal desire is to get to work, in the evening the dominant purpose is to return home. During the day while some people are tied to their jobs, others travel in order to relax, or shop, or go to school, and these incentives provide the basic patterns of movement throughout the day.

The dominant trip purpose is, of course, to home which is the destination of nearly half of all travel (Fig. 24 and Table 5). Trips to work are next in importance and represent 28 per cent of daily travel. But if the journey home from work is also included then over half of the total travel for the Internal Area is directly associated with work. Of the remaining trip purposes, only trips to school are of general significance and they equal 10 per cent. Private business trips provide seven per cent of the total movement and, rather surprisingly, shopping contributes only six per cent of all trips. Some of these figures may appear rather low, for example trips to school and for shopping, but it must be remembered that journeys of less than half a mile were, by definition, excluded from the surveys as were all journeys that occurred completely within one subsector.

The purpose of a trip often determines the mode of travel, and conversely some modes are used primarily for one particular purpose. For the most part, a combination of modes of travel is used to satisfy each purpose, and Table 5 indicates that no single mode dominates all trip purposes. Although cars predominate in most movements, there are notable exceptions to this rule; specific examples of non-car dominance are the use of cycles for school trips, and the use of buses for shopping trips.

TABLE 5

TOTAL TRAVEL FOR THE INTERNAL AREA*
BY MODE AND PURPOSE† FOR 12 HOUR PERIOD: 1959

TRIP PURPOSE (TO)	MODE OF TRIP (NUMBER)								
	Car Drivers	*Car Passengers*	*Cyclists*	*Pedestrians*	*Bus Passengers*	*Trade Vehicle Passengers*	*Taxi Passengers*	*Train Passengers*	*Total*
Work or Firm's Business	*40,877*	5,666	28,106	2,082	10,360	1,443	201	255	88,990
School	166	1,664	*18,320*	8,204	4,364	115	21	—	32,854
Shopping	4,716	2,563	2,930	1,869	*5,662*	145	60	—	17,945
Private Business ..	*8,405*	3,883	3,447	928	4,454	665	428	—	22,210
Social-Recreational ..	*4,501*	3,534	1,869	635	2,872	115	180	—	13,706
Lunch	*910*	445	546	115	637	29	—	—	2,682
Serve Passengers ..	*3,086*	200	92	—	56	—	—	—	3,434
Change Mode ..	*660*	78	361	—	296	—	61	21	1,477
Home	35,732	13,189	*46,985*	12,274	24,463	896	808	201	134,548
TOTAL ..	99,053	31,222	102,656	26,107	53,164	3,408	1,759	477	317,846

* This excludes trips from the External Area.
† Dominant Mode for each purpose is in italics.

TIME OF TRAVEL

The time patterns of movement within the city reflect the economic workings of the city. For the most part patterns are repetitive throughout each weekday, but vary considerably at the weekends. By far the bulk of travel occurs during the weekday, and it is the regular nature of weekday travel that makes possible the analysis of patterns of movement, the delimitation of problem areas, and the forecast of traffic movements.

PERSONAL MOVEMENT

The time pattern of personal travel to the Central Traffic District in Christchurch has three distinct peaks—early morning, midday, and late afternoon (evening) (Fig. 25). The evening peak is the most concentrated, and therefore the greatest. It reflects the 'emptying' of the Central Traffic District as businesses close down for the day and the area loses its power of attraction. In terms of total traffic moving over half-hour periods the midday peak is more significant than the early morning peak although, of course, of much shorter time span and therefore of less significance in terms of total volume.

The midday peak appears to result from two factors. Firstly, the midday lunch hour is the only daytime hour for personal shopping and other trips by people working outside the Central Traffic District. Much of this movement would be oriented towards the dining and shopping facilities of the centre or would use it as a convenient place for 'private business'. Secondly, a large number of people go home for lunch each day because the distances involved between business and residential sectors of the city are short and can be completed quite easily in an hour. A larger city generates a certain amount of friction against lunch time journeys because of the time-distance factor involved.

The other peak of traffic is in fact a 'double peak' catering for the early morning traffic. Whereas the evening and lunch time inflow and exodus is concentrated within a small period of time, the morning peak extends over an hour and a half (7.30 a.m. to 9 a.m.). In terms of total volume of movement it is more significant than the more concentrated midday peak.

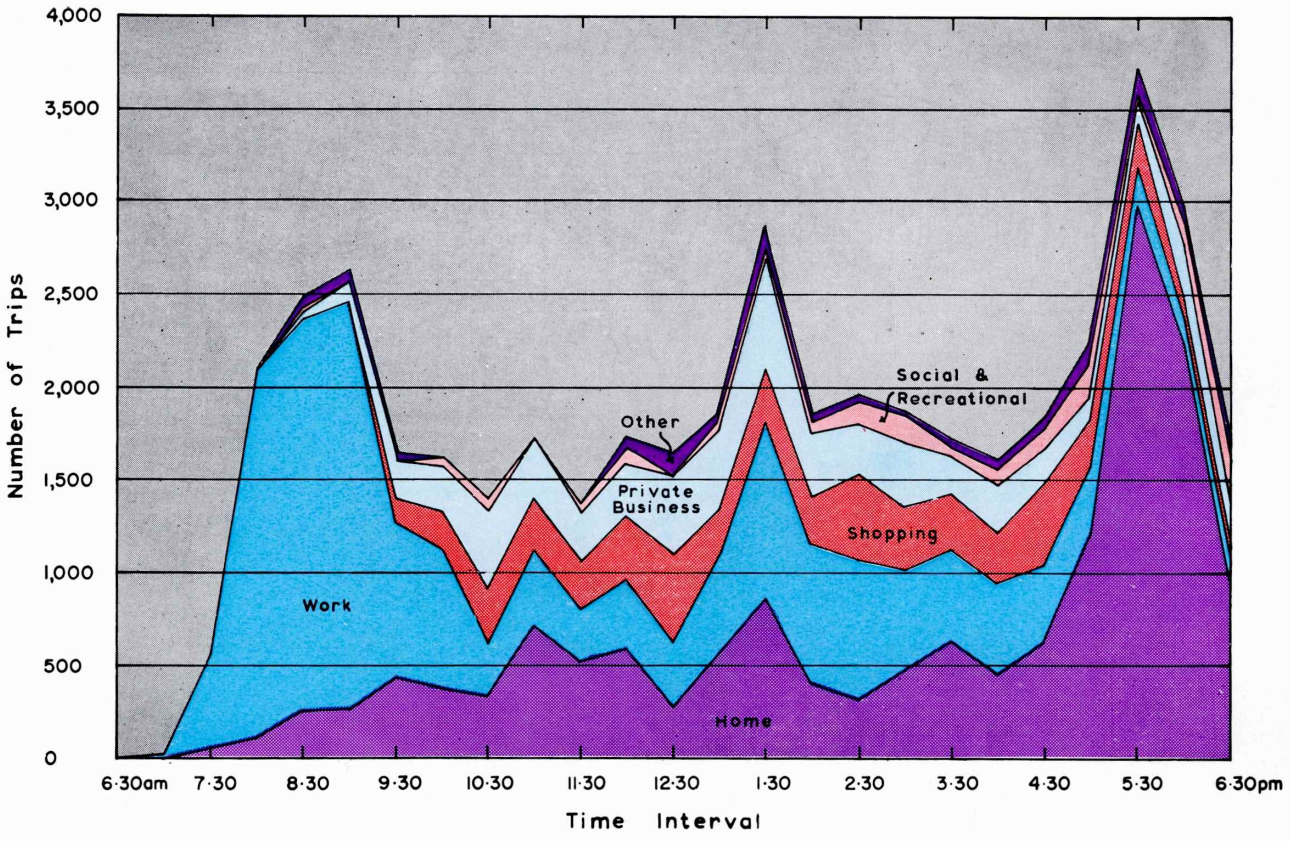


Fig. 25. TIME AND THE PURPOSE OF TRAVEL TO AND FROM THE CENTRAL TRAFFIC DISTRICT, 1959.

VEHICULAR MOVEMENT

The total pattern of vehicular movement is best explained by dealing with the individual modes and purposes. There is, for instance, a marked difference between the patterns of trade vehicle and passenger car movements with respect to the Central Traffic District (Figs. 26 and 27). Whereas the critical hours for cars coincide with the peak movements of people, trade vehicle movements are a significant part of travel between peak periods. It is reasonable to assume that trade vehicle trips will be largely confined to the 'hours of business' prevailing in Christchurch, and this hypothesis is substantiated by Figure 27. Trade vehicle movements appear well distributed throughout business hours (8.30 a.m. to 5.30 p.m.) but have only minor importance at other times.

This pattern is in contrast to the total movement of passenger cars which has an 'enforced' congestion during the peak hours because of social conventions relating to hours of work and meal times. It is in particular the peaks of passenger car traffic that provide the headaches for city planners and transport authorities.

TIME AND PURPOSE

Each of the major trip purposes has a distinctive pattern of travel in time (Fig. 25). Journeys to work, for instance, provide the bulk of arrivals in the Central Traffic District. Whereas the greatest volume of trips undertaken for this purpose are concentrated in the prework period (i.e. prior to 9.00 a.m.) it is interesting to note the general trend and, in particular, to see how the end of the lunch hour induces a secondary peak at 1.30 p.m. Trips from work offer a direct reversal of the 'to

work' pattern, in that early morning trips are least significant and evening trips are most significant.

Shopping trips have two distinct maxima—one in the midmorning between 10.00 a.m. and 11.00 a.m., and another in midafternoon between 2.00 p.m. and 4.00 p.m. These two periods are times in which there is no 'rush hour' stress on the housewife and, therefore, represent hours when she could conveniently go shopping. Trips described as private business reflect the traditional refreshment periods of midmorning, lunch time and midafternoon. This purpose is rare before 9.30 a.m. and after 4.30 p.m.

An analysis of the twelve hours from 6.30 a.m. to 6.30 p.m. does not provide a good measure of social and recreational trips because most of these occur after 6.30 p.m. Although daytime figures do not place these two purposes in proper perspective in relation to total travel, the figures do show the concentration of trips of this type immediately before and after the afternoon film sessions.

Taking the 12 hour period as a whole, significant deviations from the mean hourly movement occur only for short periods in the morning and evening and at midday. But these deviations are all important for they form the crux of the traffic problem. Whereas the internal roading system is generally adequate for average traffic at the present time, peak hour traffic is typified by overcrowding on the main outlets, low speeds of movement, delays at intersections, and higher probabilities of accidents. Traffic will continue growing and this will, of course, increase the scale of the problems already in existence as well as create new ones.

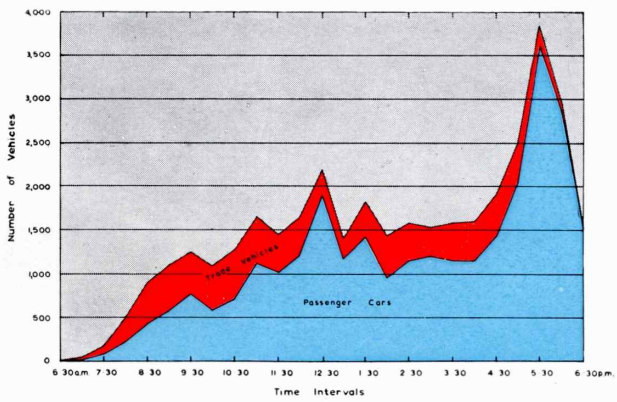


Fig. 26. Time and the movement of passenger cars and trade vehicles from the central traffic district, 1959.

CONGESTION POINTS

Although the majority of streets in Christchurch are adequate for the present average hourly flow of vehicles, it is apparent to anyone driving to and from the city centre during the peak hours that a number of intersections and routes are used at very nearly their capacity. Only strict regulation by traffic officers and control by traffic signals permit a relatively continuous and safe flow.

The natural tendency of a traveller on his way to work or to home is to choose the quickest and most convenient route. This usually results in large numbers of travellers selecting routes that have advantages such as centrality or lack of obvious obstructions. The outcome of course is the accumulation of traffic along selected roads. The problem associated with this accumulation is to avoid congestion and maintain the speed and freedom of movement that originally attracted traffic to the route.

Within Christchurch it is possible to isolate a number of major radial routes along which the bulk of suburban traffic is channelled. Accumulation of vehicles along these routes becomes greater as the central city area is approached (Fig. 22), and very real problems occur at the intersections of radial roads and principal feeders, or where major routes join.

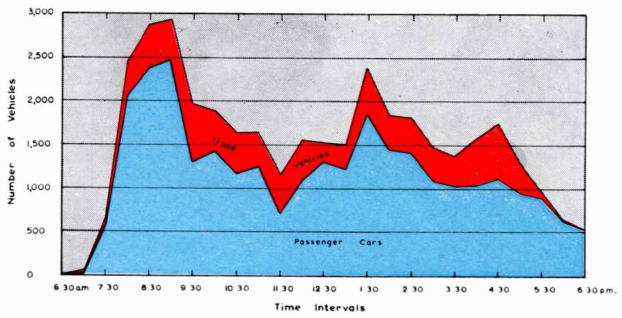


Fig. 27. Time and the movement of passenger cars and trade vehicles to the central traffic district, 1959.

TABLE 6

CHARACTERISTICS OF PARKING IN THE CENTRAL TRAFFIC DISTRICT FROM 9.30 A.M. TO 4.30 P.M.: 1959

TRIP PURPOSE	Number Parking	Average Duration of Parking	Space-Hours	
			No.	%
Work	7,168	6 Hours 40 minutes	47,750	57
Business	8,718	2 Hours 10 minutes	18,900	23
Work after lunch	2,034	2 Hours 10 minutes	4,420	5
Shopping	2,698	1 Hour 40 minutes	4,480	5
Social-Recreational	1,484	1 Hour 55 minutes	2,850	3
Trade Vehicles	7,234	50 minutes	6,030	7
		TOTAL	84,430	100

PARKING

Similar to that of congestion on routes is the problem of providing adequate parking space for the vehicles that are used daily in transporting people from point origins to point destinations. This is intensified where there is a large accumulation of vehicles in a small area, as occurs in and about a central business district. In Christchurch the city centre has insufficient parking space to cater for all vehicle users and there is a considerable spread of parking into adjacent streets.[5]

Within the Central Traffic District as a whole there are approximately 10,500 'spaces' on and off the street that can be used by the transient population of the central area. Of the total spaces available within the Central Traffic District 55 per cent represent on-street parking and the balance is available to off-street parkers (Fig. 28). Traffic authorities claim that 85 per cent utilisation of vehicle parking space represents saturation; the remaining 15 per cent of spaces is required for the normal processes of parking and to provide a satisfactory level of availability of spaces. The parking survey of the Central Traffic District showed that the greatest demand for parking space occurs in the area bounded by Hereford Street, Oxford Terrace, Lichfield Street and Manchester Street. Here on-street parking appears to be completely saturated with over 90 per cent of parking spaces being occupied (Fig. 28). On-street parking is heavily utilised over the whole central area, but the pressure is not so great for off-street parking; in some areas, as little as 41 per cent of total space is used.

The greatest use of vehicle parking space results from the parking of vehicles needed for the daily journey to work. This type of parking is of the longest average duration and occupies approximately 57 per cent of the total space-hours required by all vehicles in the Central Traffic District[6] (Table 6). This is in direct contrast to the shorter periods of parking typical of shopping and trade vehicle trips. It also appears to indicate that any solution to the parking problem must revolve around supplying adequate long-term parking for the commuter, short-term parking for shoppers and the like, and spaces for trade vehicles and buses.

TYPE OF TRIPS

Whereas the classification of trips by time, purpose and mode of travel is an obvious approach to analysis and forecasting, other groupings are also significant in examining traffic distribution and patterns. To obtain a picture of the proportion of traffic which, although not now doing so, could bypass the Central Traffic District or other major

[5] Liberal allowance was made in the parking survey by analysing the whole of subsector 01 which includes a large part of the central business district and adjacent streets.

[6] Total space-hours is the sum of the number of trips of each selected purpose multiplied by the average duration of parking for that trip purpose. Parking problems are further discussed in Chapter Six.

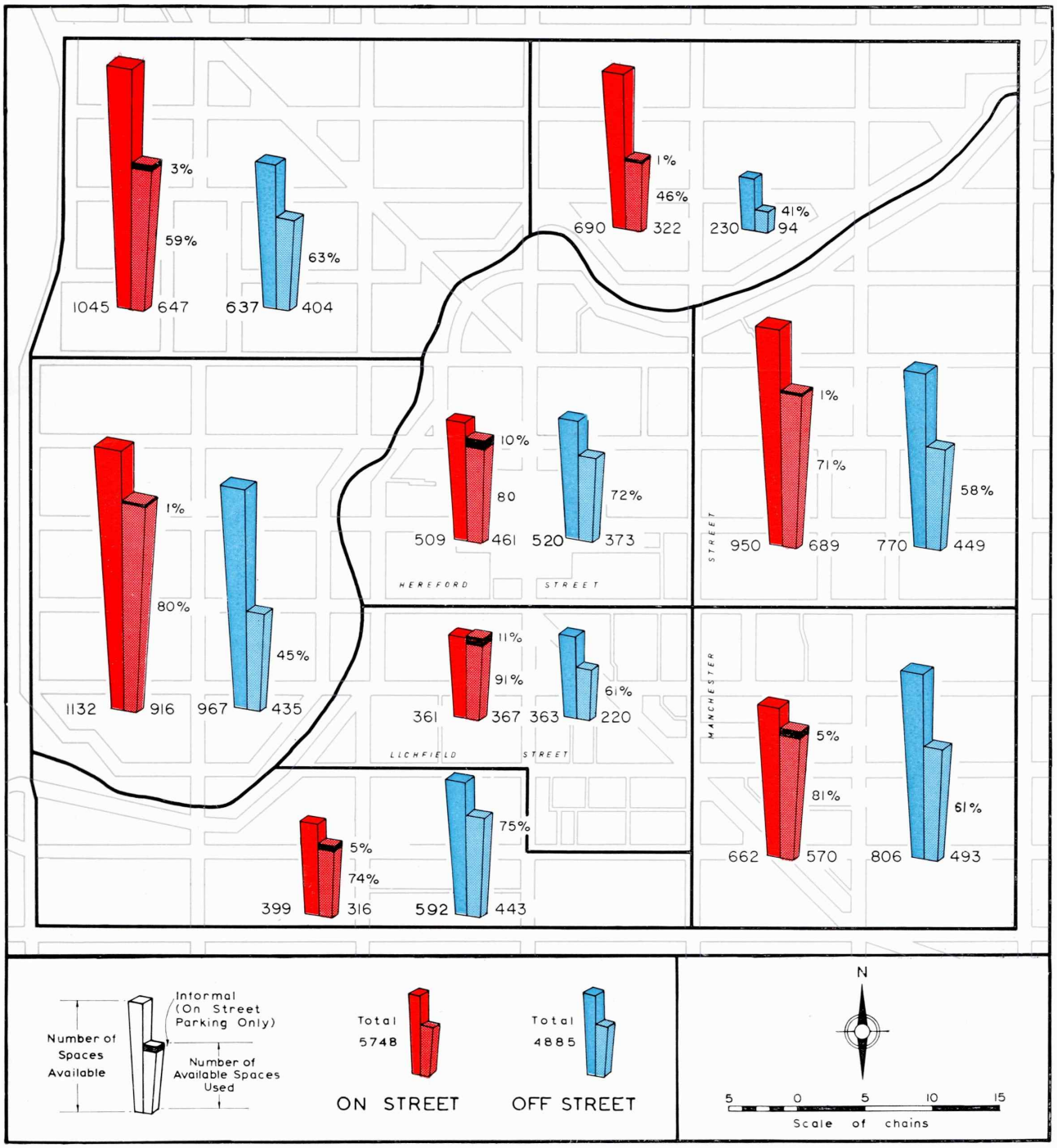
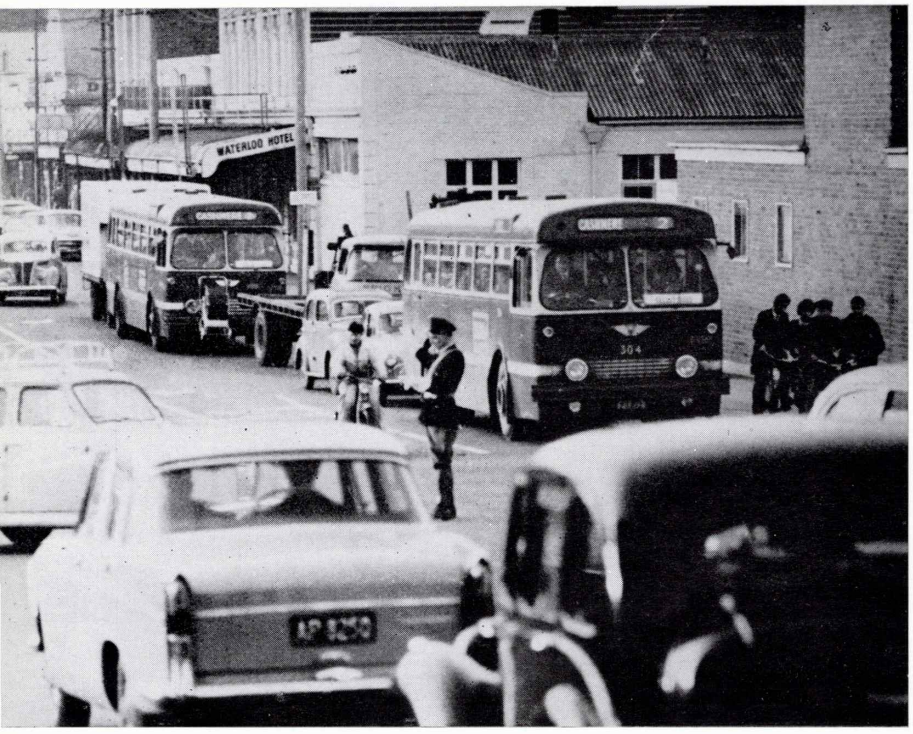


Fig. 28. Parking within the central traffic district, 1959: supply and demand. For seven hours (9.30 a.m.-4.30 p.m.) on an average weekday: 85 per cent utilisation of available spaces represents saturation.

Plate XVII

Central Problems

'. . . . somewhere to park . . . .'



'. . . . peak hour traffic is the crux . . . .'

'. . . . informal parking . . . .'

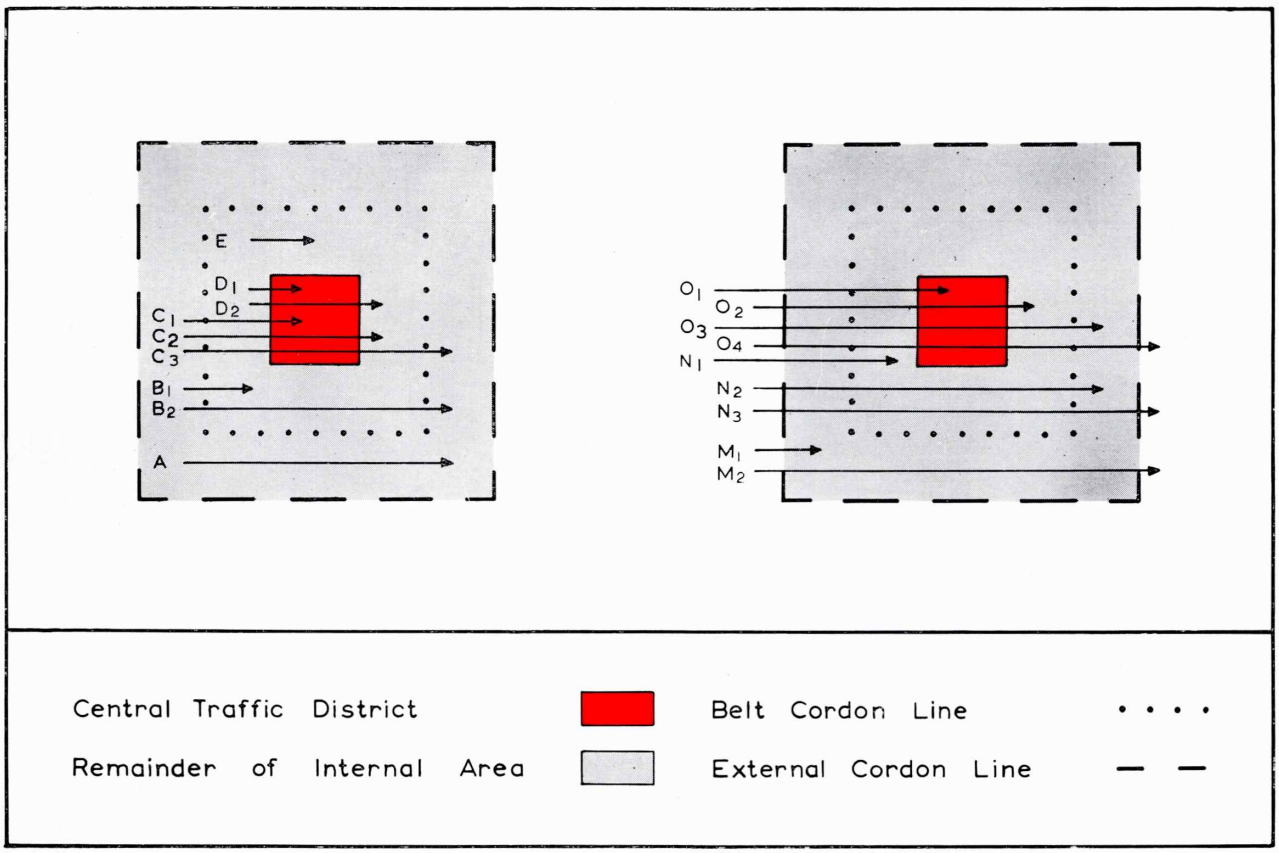


Fig. 29. POSSIBLE TRIP TYPES BASED ON ORIGIN AND DESTINATION. With respect to the Cordon Lines there are 18 possible trip types.

areas, a special grouping of trips according to generalised origins and destinations was carried out. With respect to the cordon lines set up for the purpose of sampling travel and traffic, the overall pattern can be reduced to 18 possible trip types (Fig. 29): the numerical value of each of the trip types is given in Table 7.

The analysis of trip types with reference to the Internal Area as a whole shows that there is no demand at the present time for a bypass to take external traffic that passes through the Internal Area without stopping (Fig. 30). For the 12 hour period only three per cent of the external traffic entering the Internal Area was through traffic. There is, however, an appreciable volume of traffic—mostly Internal—passing through the Central Traffic District which could use convenient bypass facilities. In the 12 hour period 29 per cent of the traffic entering the Central Traffic District had no purpose in entering the area other than being cross-city traffic following the shortest route between origin and destination.

All of the 18 possible trip types are not of course equal in importance, for over two thirds of all trips consist of either journeys to the Central Traffic District or intersuburban trips not crossing the Belt Cordon Line (Table 7, Types C_1, D_1, O_1, A). For example, the Type A trip (which does not cross the Belt Cordon Line) is the most popular type of trip and almost equals the total movement of people to the Central Traffic District. However, a closer analysis of this trip type reveals that the largest single purpose is the journey to and from school. As the majority of schools in Christchurch are located outside the Belt Cordon Line (as is

TABLE 7

MAJOR TYPES OF TRIPS BASED ON ORIGIN AND DESTINATION, BY SELECTED MODE OR PURPOSE FOR 12 HOUR PERIOD: 1959

MODE OR PURPOSE OF TRIP	TYPE OF INTERNAL TRIP BASED ON ORIGIN AND DESTINATION* (NUMBER)								
	A	B_1	B_2	C_1	C_2	C_3	D_1	D_2	E
Passenger Cars and Taxis	35,084	9,396	6,768	39,391	4,798	4,662	5,444	363	429
Trade Vehicles ..	14,041	4,873	2,224	8,729	1,240	1,163	4,443	56	483
TOTAL VEHICLES ..	49,125	14,269	8,992	48,120	6,038	5,825	9,887	419	912
BUS AND TRAIN PASSENGERS	8,028	4,919	2,320	31,743	2,715	2,379	1,489	86	49
TOTAL PEOPLE (all modes)	121,642	30,947	17,107	110,472	12,427	10,937	13,977	1,026	1,295
Total People Excluding School Children ..	72,192	23,047	16,362	106,720	11,029	9,766	12,955	960	809
TOTAL SCHOOL TRIPS ..	49,450	7,900	745	3,752	1,398	1,171	1,022	66	486
School Trips by Cycle	26,822	5,204	728	2,406	536	477	634	22	251
Total Cycles Excluding School Cycle Trips	21,880	8,086	3,915	23,844	3,372	1,652	3,713	269	311
TOTAL CYCLES ..	48,702	13,290	4,643	26,250	3,908	2,129	4,347	291	562
	TYPE OF EXTERNAL TRIP BASED ON ORIGIN AND DESTINATION* (NUMBER)								
	M_1	M_2	N_1	N_2	N_3	O_1	O_2	O_3	O_4
Passenger Cars and Taxis	7,056	138	318	726	22	4,816	158	586	7
Trade Vehicles ..	2,829	82	207	590	17	1,429	84	190	1
TOTAL VEHICLES ..	9,885	220	525	1,316	39	6,245	242	776	8
BUS AND TRAIN PASSENGERS	2,526	—	783	750	—	2,679	255	578	—
TOTAL PEOPLE (all modes)	16,019	301	1,400	2,324	55	12,409	569	1,894	17

* See Figure 29 for illustration of type of trip.

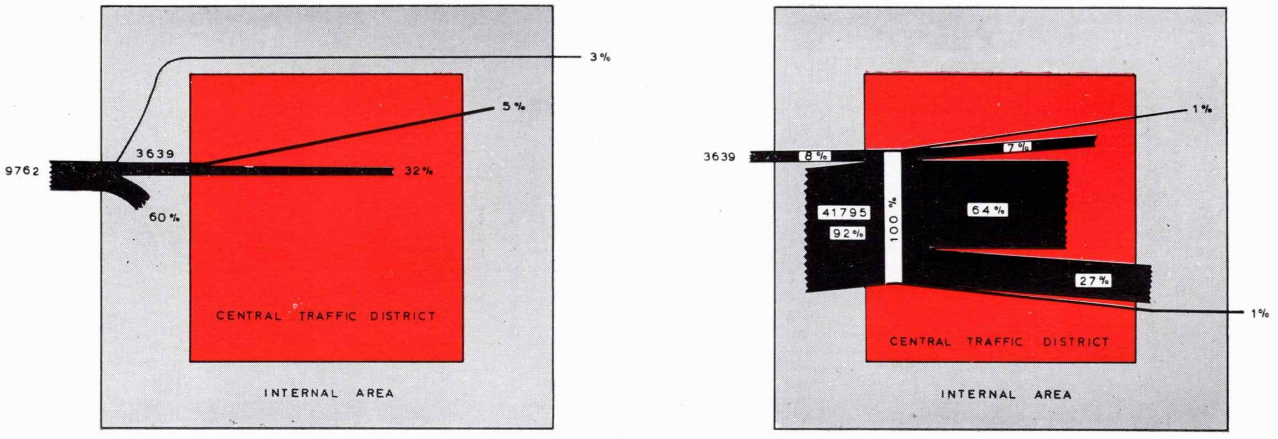


Fig. 30. MAJOR TYPES OF TRIPS BASED ON ORIGIN AND DESTINATION, 1959. In the left diagram, only external traffic is considered: in the right diagram, all traffic (external and internal) is considered. For 12 hours (6.30 a.m. - 6.30. p.m.) on an average weekday. *See Table 7.*

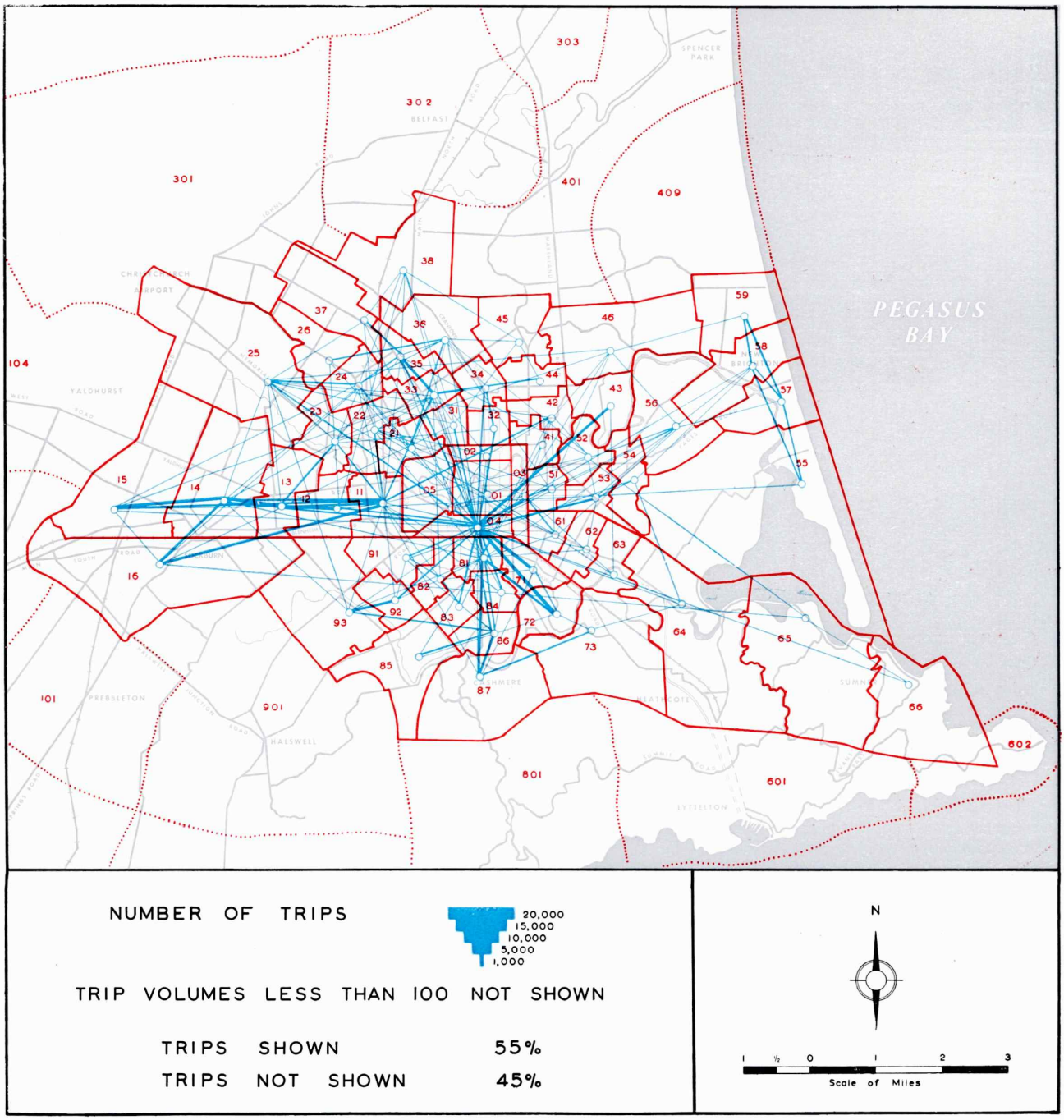


Fig. 31. Desire lines for private cars and taxis between suburban subsectors, 1959. Travel between internal subsectors (excluding the Central Traffic District) for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

over 90 per cent of the city's population), the combination of school traffic and other internal traffic not crossing the Belt Cordon Line produces a force in the total travel pattern that cannot easily be ignored. There is a direct contrast however, between trips of this type—for which there is a great variety of different origins and destinations—and the more focal nature of travel to the Central Traffic District. In the former case the relatively large number of suburban traffic nodes gives a fairly complex pattern of trip desire lines (Fig. 31); in the latter case the point origin (or

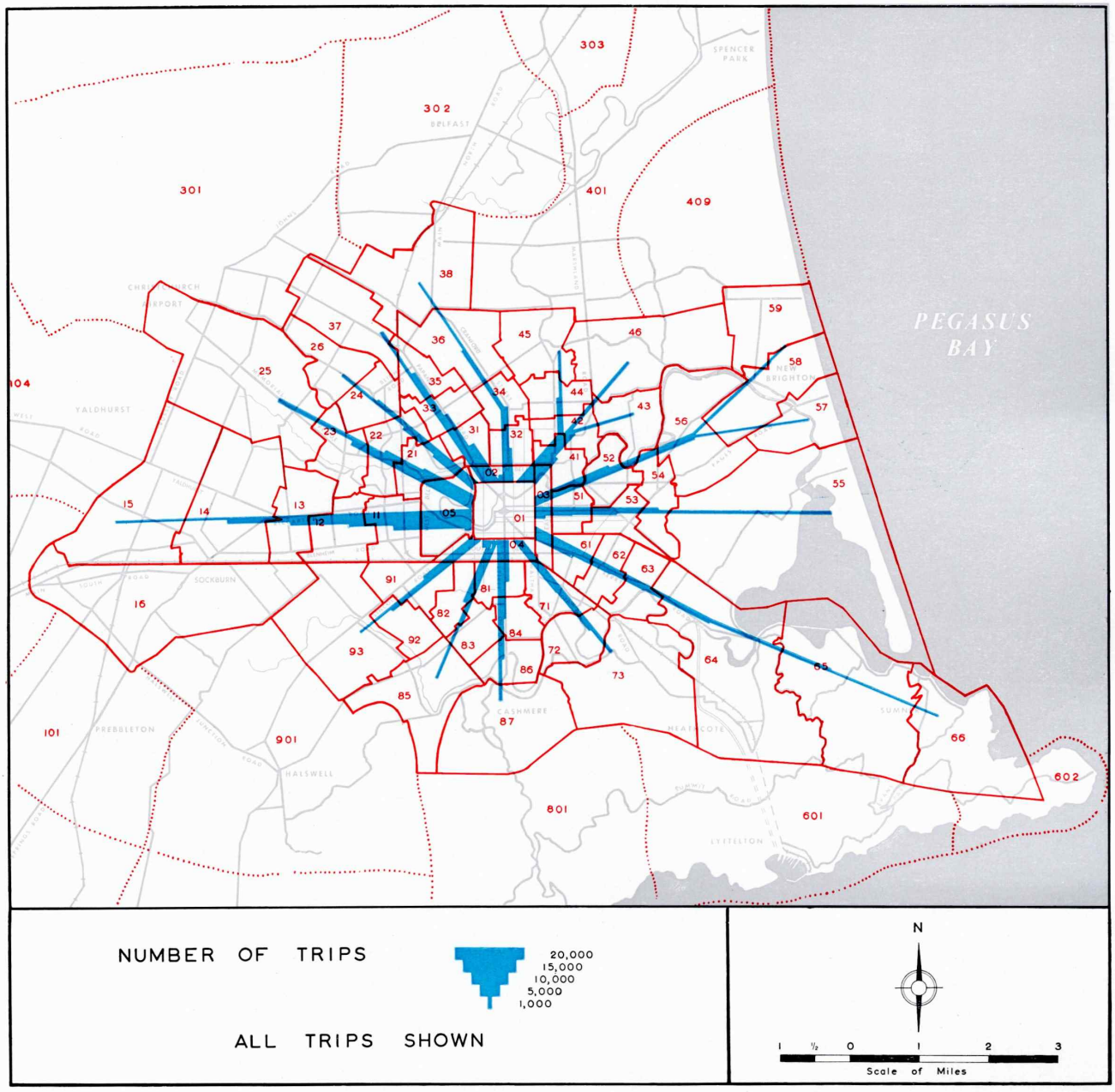


Fig. 32. Desire lines for private cars and taxis between the central traffic district and suburban subsectors, 1959. Travel for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

point destination) offered by the Central Traffic District regiments the patterns of travel so as to produce cumulative desire lines that show quite clearly the dominance of the Central Traffic District as a regional traffic node (Fig. 32). In short, no other single node attracts anywhere near the volume of traffic that is oriented toward the Central Traffic District.

TABLE 8

TRAVEL TO THE CENTRAL TRAFFIC DISTRICT, BY MODE AND PURPOSE FOR 12 HOUR PERIOD: 1959

TRIP PURPOSE	MODE OF TRIP (NUMBER)				
	Car Drivers	*Motor, Power and Pedal Cyclists*	*Bus and Train Passengers*	*Other*	*Total*
Work	7,168	8,283	6,720	3,067	25,238
Business	8,718	2,392	3,244	4,166	18,520
School	—	853	313	294	1,460
Work after Lunch	2,034	1,434	559	382	4,409
Shopping	2,698	1,084	5,682	2,751	12,215
Social and Recreational ..	1,484	318	759	1,134	3,695
Home	1,044	1,041	357	745	3,187
TOTAL	23,146	15,405	17,634	12,539	68,724*

* If we assume the law of directional symmetry in travel applies to Christchurch then movements *to and from* the Central Traffic District would be approximately double this figure.

Taking into account the focal nature of the Central Traffic District as against the multiplicity of local foci outside the Belt Cordon Line, it is clear that the Central Traffic District is the principal single traffic generator. The principal direction of flow can therefore be summarised in three types: firstly, movement to the Central Traffic District; secondly, movement between internal subsectors other than that of the Central Traffic District; and thirdly, movement between localities in the External Area and subsectors in the Internal Area. Each of these trip types has distinctive features, particularly in relation to the mode and purpose of travel, as well as to the basic land use patterns and population characteristics that, in combination, generate travel. For purposes of convenience and understanding, the characteristics of each of these types of trip will be examined in detail.

It is apparent from Table 7 (Types M_2, N_3, O_4,) that the number of trips which are made from one external locality to another external locality and involve a journey through any part of the Internal Area without stopping is very small—only 373 person trips out of a total of approximately 355,000 occurring in the Internal Area, and only 267 vehicle trips out of approximately 163,000. In both cases the percentages are negligible, being less than 0.2 per cent. Therefore this group of trips is not subject to further discussion.

TRAVEL TO CENTRE

Approximately 40 per cent of the total vehicle and person trips originated in or were destined for the Central Traffic District (Table 7, Types C_1, D_1, O_1). The importance of this area to the city as a whole is at once obvious; the patterns of movement to and from the Central Traffic District account for two fifths of the city's daily travel and, consequently, go a long way towards explaining the economic activities of the city itself. In particular, the explanation of patterns of travel to the Central Traffic District is a big step towards forecasting a large part of the future traffic without relying on the Fratar method which had to be used to distribute the balance of the total trip generation.

The most important trip purpose behind the inward movement of people and traffic is the desire to work (Table 8). Next in order are business and shopping trips.[7] Cars dominate the mode of travel generally but other modes are more important for particular purposes (e.g.

[7] The Central Traffic District contains the major theatres and other social-recreational attractions but trips of this type do not show up because of the time limitations of the original sample (6.30 a.m.—6.30 p.m.).

TABLE 9

MODE OF TRAVEL AS PERCENTAGE OF TRIPS TO THE CENTRAL TRAFFIC DISTRICT, BY ZONE: 1959

ZONE*	APPROXIMATE DISTANCE FROM CITY CENTRE (IN MILES)	MODE OF TRIP											
		Car Drivers		*Motor, Power and Pedal Cyclists*		*Bus and Train Passengers*		*Car Passengers*		*Pedestrians and Others*		*Total*	
		No.	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%	*No.*	%
I	0.5—1.0	2,141	31.9	2,067	30.8	656	9.8	353	5.3	1,493	22.2	6,710	100
II	1.1—2.0	7,680	30.2	7,728	30.4	6,677	26.2	2,556	10.0	807	3.2	25,448	100
III	2.1—3.0	6,232	36.3	3,925	22.8	4,792	27.9	1,896	11.0	349	2.0	17,194	100
IV	3.1—4.0	2,989	41.4	1,195	16.5	1,816	25.2	779	10.8	442	6.1	7,221	100
V	4.1—5.0	1,265	36.7	310	9.0	1,172	34.0	578	16.8	120	3.5	3,445	100
VI & VII	5.1—7.0	783	28.6	134	4.9	1,025	37.5	694	25.4	98	3.6	2,734	100

* See Figure 75 in Appendix I for illustration of zones.

shopping and to work). The desire line maps (Figs. 32 and 31) show firstly, the concentration of traffic flows to the Central Traffic District, and secondly, the relative number of trips which are likely to pass through the central area. Desire line maps show the sum of all straight lines connecting pairs of origins and destinations. Such lines are often unrealistic, for the routes shown may not exist within the framework of existing streets. Diagrammatically however, the maps do give a strong and unbiased impression of the location and magnitude of travel.

MODE

BY CAR

Of the various ways and means of getting people to and from the Central Traffic District, the private motor car stands out as the most significant. The emphasis on car travel however differs considerably from one part of the city to another. It also varies with distance from the Central Traffic District (Table 9).

In terms of 1959 car traffic, the maximum numbers occur in a broad zone one to two miles from the city centre (Zone II), while cars as a proportion of total traffic are highest in Zone IV (three to four miles from the centre) with 41 per cent. Beyond this Zone the proportion for car drivers decreases but this is compensated by an increase in the proportion of car passengers, indicating a more efficient use of the car as distance from the centre increases. It can be seen that the combined percentages of car drivers and car passengers are almost equal for outer Zones IV, V, VI and VII. It might be expected that the combined percentages would rise more noticeably with distance. In Christchurch special features appear to prevent this occurring; for instance, some of the more distant and lower valuation suburbs are relatively well served by bus routes and in the newer, peripheral suburbs the householders are in the expensive process of settling in and appear to use bus travel as a cheaper means of movement.

The greatest number of inward car trips originate in the area relatively close to the Central Traffic District and in the general wedge of suburbs to the northwest (Fig. 33). Apart from these areas, isolated cores of high density car travel to the Central Traffic District occur in subsectors 87 and 92. Subsectors in which car travel is least important generally coincide with areas of very low car ownership per household.

A significant proportion of the trips to the Central Traffic District originate in the northwestern area. This seems to indicate that most of the people from this area work in the city centre whilst inhabitants of other suburbs appear to have more varied work places.

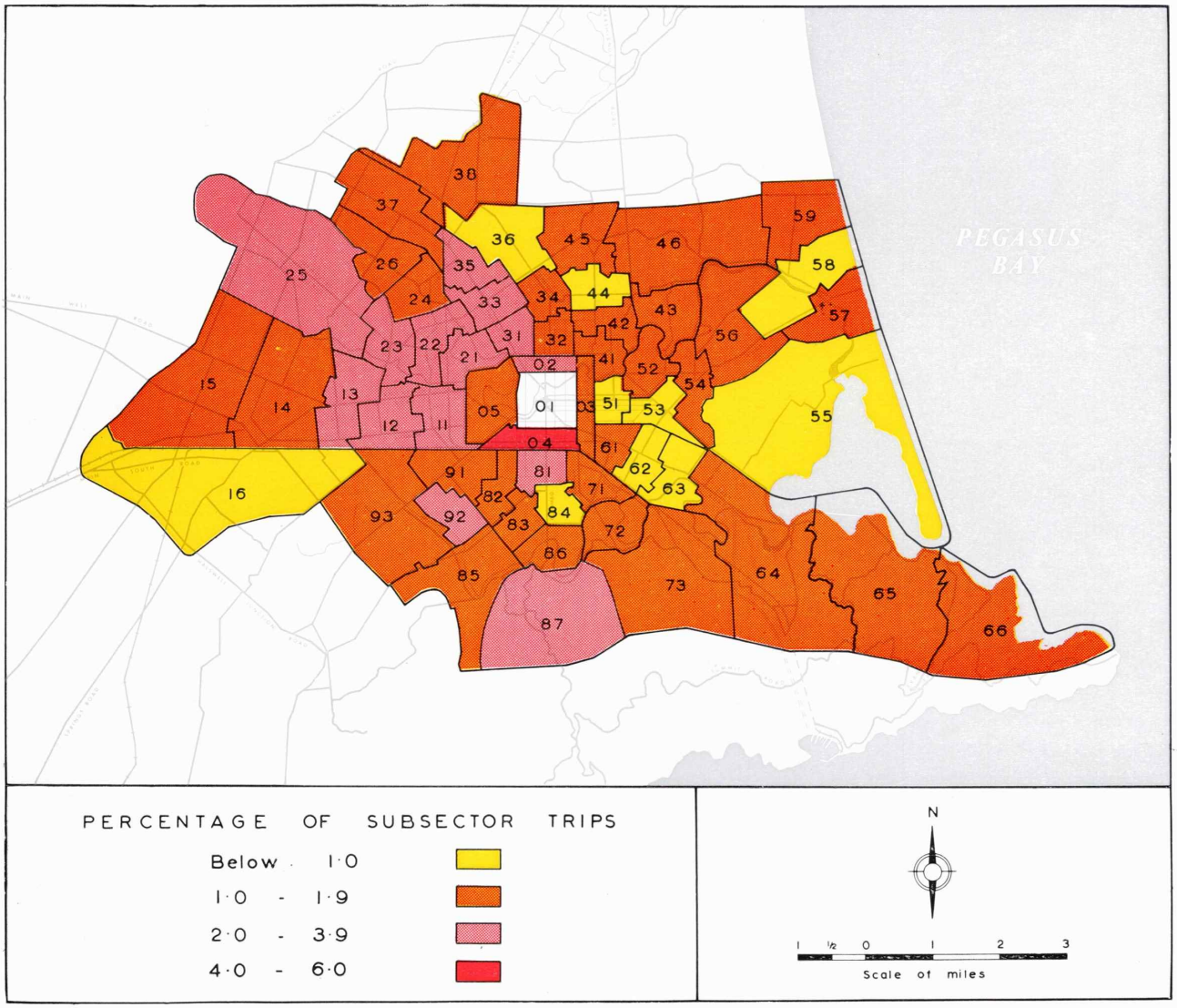


Fig. 33. TRAVEL TO THE CENTRAL TRAFFIC DISTRICT BY CAR, 1959. Travel (passenger cars and drivers) to Central Traffic District from each subsector by car is expressed as a percentage of total travel to Central Traffic District from all subsectors by car, for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

BY CYCLE

The trip pattern of cyclists (motor, power and pedal) is virtually a reversal of the pattern of car movements. This mode achieves greatest significance in Zones I and II (0.5 to two miles), and for the city as a whole there is an inverse relationship between distance and travel by cycle.

The cycle has many advantages over other modes of travel. It is easily manoeuvred, suffers little depreciation with daily use, has few running costs, and produces no great parking problem. As distance increases however, the time and energy spent in cycling appear to cancel out these advantages, and cycle trips diminish as distance increases.

The origins of pedal cycle trips vary markedly from those of motor and power cycles and are concentrated in the inner suburbs (Fig. 34). In

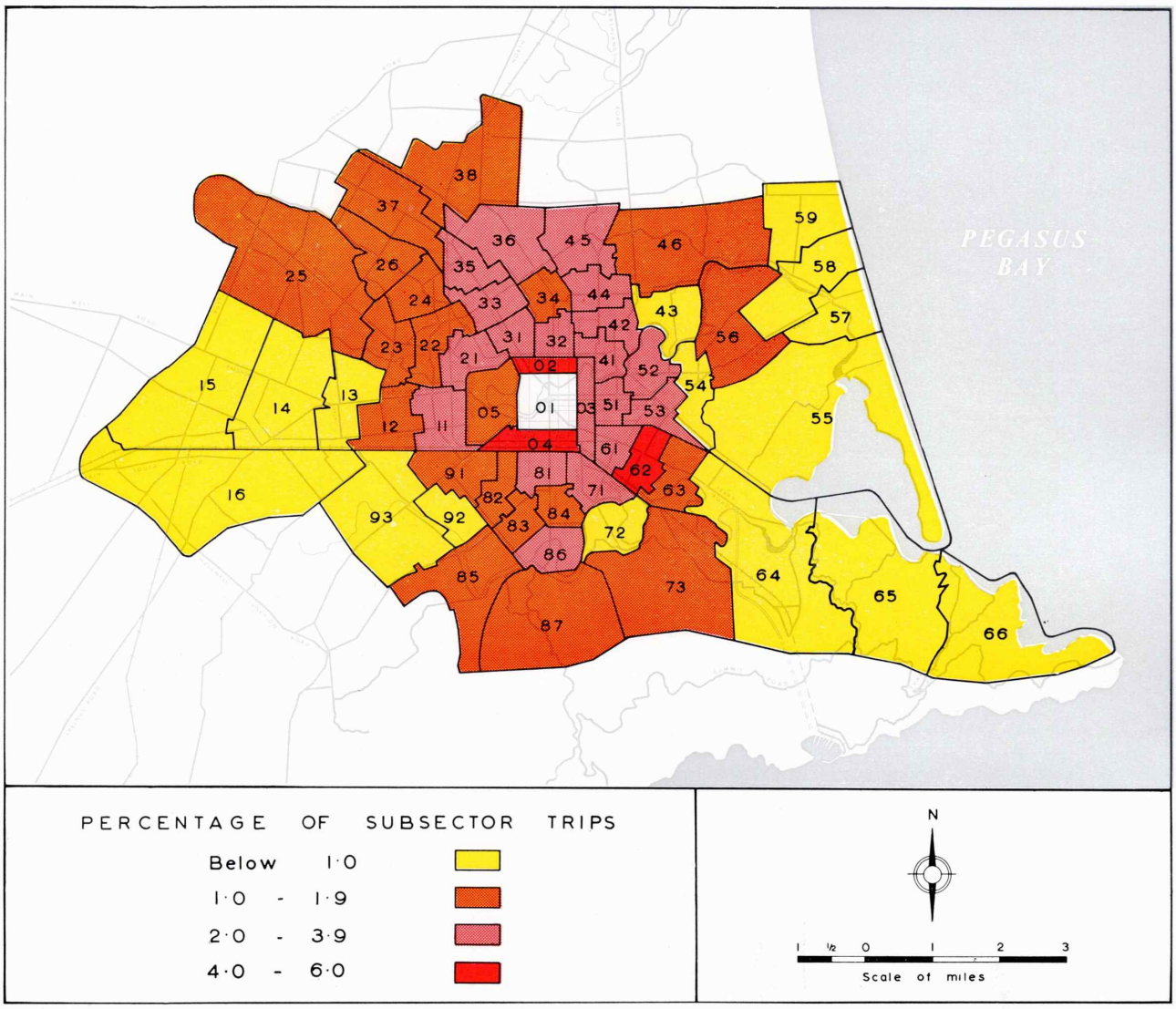


Fig. 34. TRAVEL TO THE CENTRAL TRAFFIC DISTRICT BY PEDAL CYCLE, 1959. Travel to Central Traffic District from each subsector by pedal cycle is expressed as a percentage of total travel to Central Traffic District from all subsectors by pedal cycle, for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

addition two significant wedges extend along Papanui Road and Cranford Street. Motor and power cycles on the other hand give a more diffused pattern as they can more readily handle distance. Areas of high density occur in the north and northeast, and in subsector 04. A zone of low density trip generation occurs in the south and west. Among the western suburbs only Riccarton Borough has any marked concentration of originating trips.

BY BUS AND TRAIN

Mass movements by bus and train rank second in importance to cars as a means of personal transport to the Central Traffic District and, on an

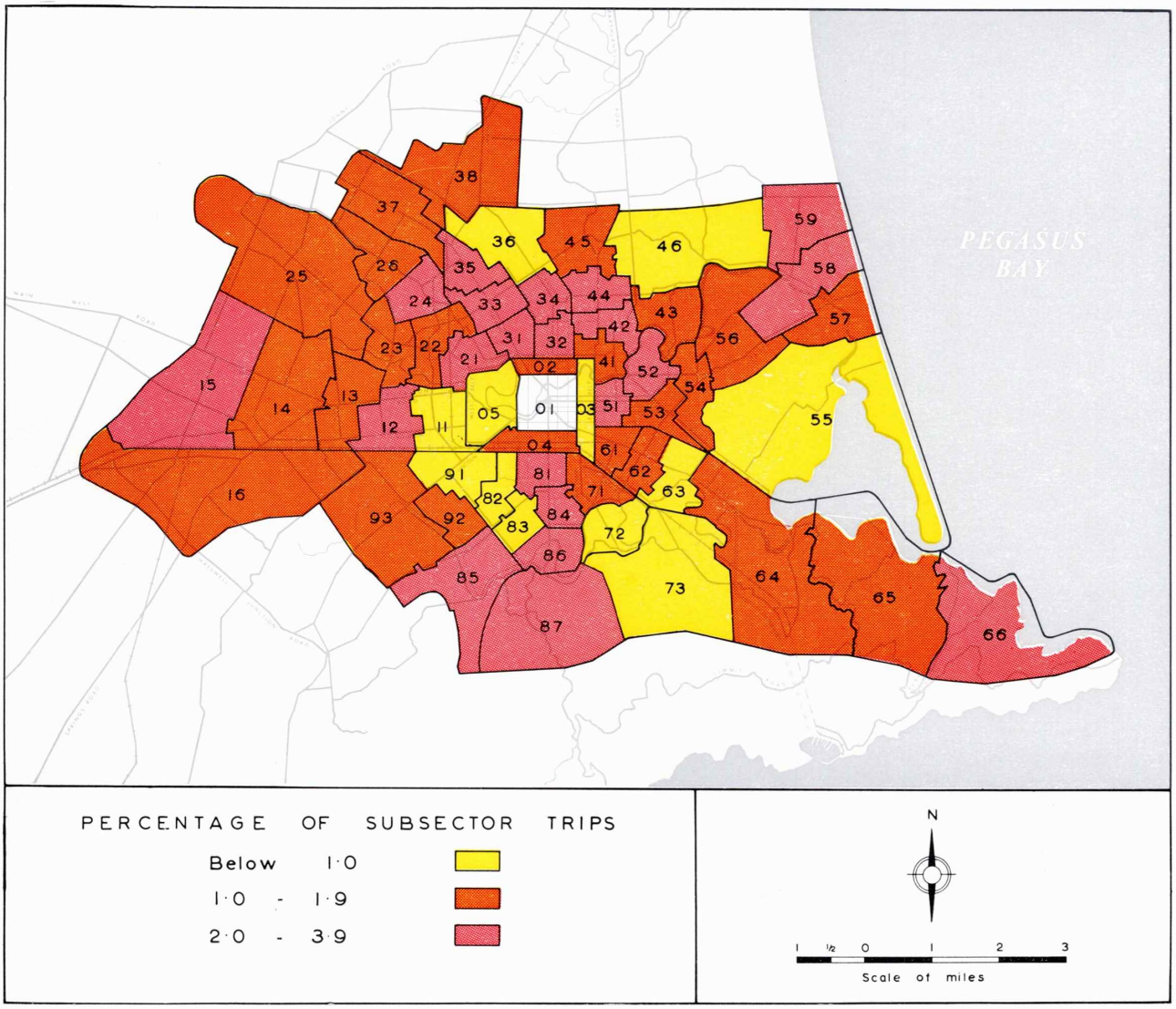


Fig. 35. Travel to the central traffic district by bus, 1959. Travel (bus passengers) to Central Traffic District from each subsector by bus is expressed as a percentage of total travel to Central Traffic District from all subsectors by bus for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

average weekday in 1959, there were 17,600 trips using these modes. Bus transport is considerably more important than trains, reflecting the difficulties in developing a satisfactory suburban rail system in Christchurch.

Although the largest number of bus trips are for short distances, buses account for only a small percentage of the travel from Zone I to the Central Traffic District. Bus travel as a proportion of total travel is greatest in the outer zones. The sources of bus passengers tend to be fairly regularly distributed through the Internal Area, except for some subsectors of low density adjacent to the Central Traffic District (Fig. 35). The relative importance of this mode is retained despite increasing distance, as it offers the only feasible,

alternative means of transport for a household in which the bread-winner uses the household car for travel to work.

An analysis of the origins of bus travel by subsectors shows high densities of bus travel along a north-south axis including, in the north, Papanui Road - Mays Road - Cranford Street routes in particular, and, in the south, the Colombo Street to Cashmere route. Apart from this north-south axis, concentrations occur in the New Brighton area (subsectors 58-59), Sumner (subsector 66) and Hei-Hei (subsector 15). Low densities in subsectors 36, 46, 55 and 73 are explained in part by the paucity of services in these areas.

BY OTHER MODES

Trips to the Central Traffic District by other modes of transport, for example, pedestrians, taxi passengers, car passengers and trade vehicle passengers, give a rather diffuse pattern and achieve significance in the total pattern only in Zone I where together they account for 27.5 per cent of total travel and in the outermost Zone where they represent 29.0 per cent. The two most important modes in this category are pedestrians and car passengers.

Pedestrian trips are largely local in nature but a shallow wedge extends along Papanui Road and along the north side of Hagley Park. Distance generally precludes other pedestrian trips to the Central Traffic District. The number of car passengers on the other hand tends to increase with distance from the centre and this mode appears to be most important in a wedge north and west of Hagley Park. The pattern for the rest of Christchurch is rather haphazard.

BY TRADE VEHICLES

Trade vehicle movement is the last mode of any importance in the pattern of movement between internal subsectors and the Central Traffic District. For the most part trips are confined to subsectors adjacent to the Central Traffic District, with important extensions along Riccarton Road (Fig. 36). The dense pattern of trips between these subsectors (03, 04 and 81) and the Central Traffic District represents the movement between railway yards, warehouses, and the central commercial business and industrial areas. These subsectors contain most of the overspill of activities associated with business and commerce and, as such, they generate strong local linkages. The remaining trips are fairly regularly dispersed through the city, reflecting a mode that specialises in household delivery.

PURPOSE

TO WORK

The very nature of the Central Traffic District—by definition a large part of the central business district and related parking area—leads one to anticipate the fact that journeys to work provide the most significant purpose for inward trips (Table 8). Employment opportunities within the city's principal retail and commercial establishments attract approximately 25,000 persons per day. If private and firm's business trips are added to work trips, these purposes account for 64 per cent of the whole centripetal movement. This is, of course, a direct reflection of the highly commercial nature of the central area.

TO SHOP

The proportionately low percentage of shopping trips (18 per cent) shows quite clearly that the people who work in the Central Traffic District are more significant, in numbers at least, than the transient population which uses the services available in the area. Not everyone shops in the central area however; normally, individuals prefer the convenience of local shops for their basic necessities such as groceries, meat, milk and bread, and make use of the range of functions in the central area for more specialised purposes. Many functional activities such as specialist clothing, furniture, chain stores and department stores are not represented in all suburban shopping centres and, in such cases, special trips to the central area are required. The amount of shopping trips entering the Central Traffic District reflects the total daily desire for specialised products rather than everyday purchases.

OTHER PURPOSES

Journeys to and from lunch, private business trips, and shopping all contribute to the daily pattern of

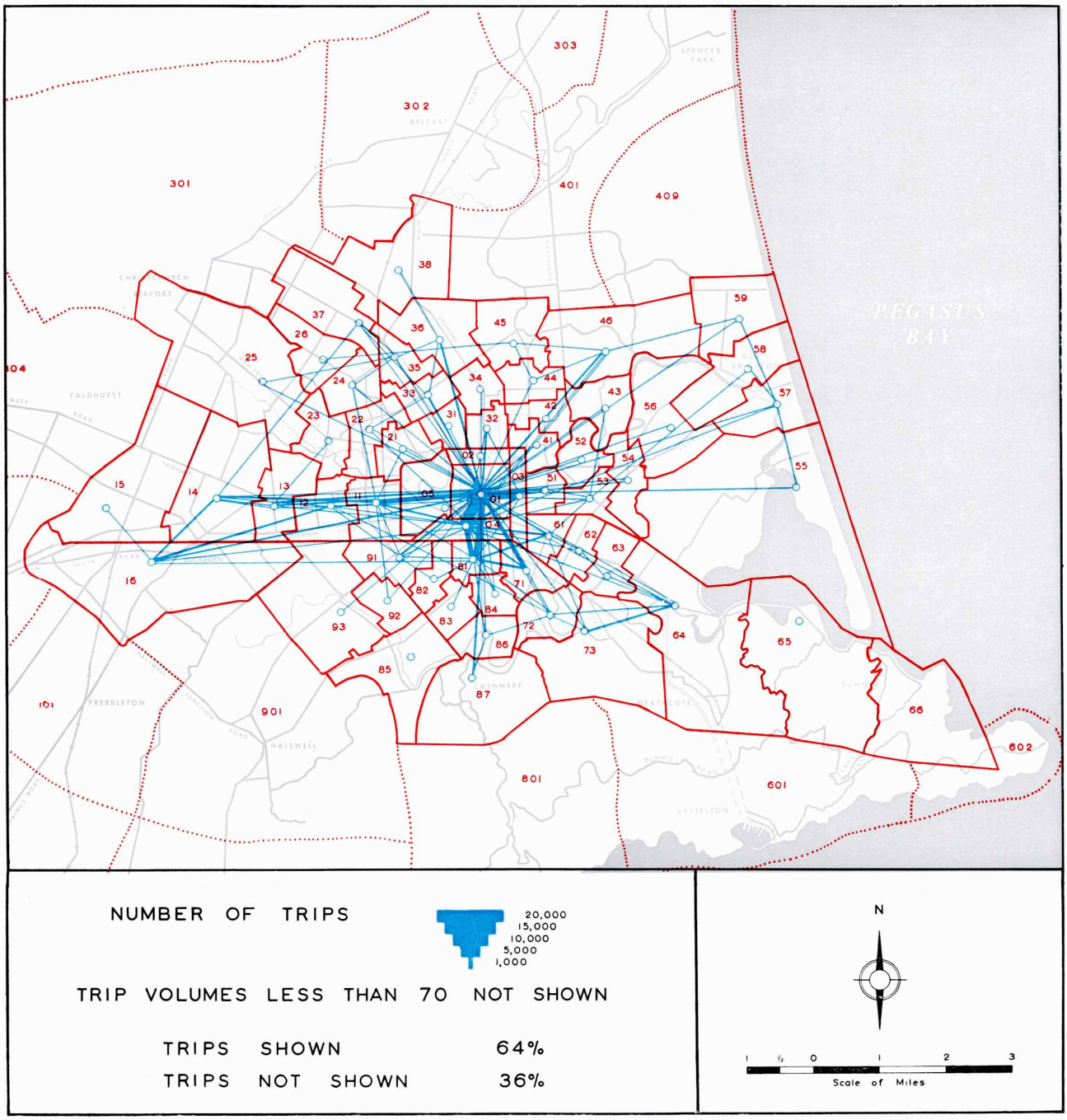


Fig. 36. Desire lines for trade vehicles between internal subsectors, 1959. Travel for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

movement within Christchurch and in particular they provide the bulk of the midday traffic peak. Because of staggered lunch hours, both in the Central Traffic District and the rest of the Internal Area, midday traffic is typified by simultaneous two way movements and forms different patterns to those of the early morning and late evening peak traffic.

SUBURBAN TRAVEL

In the case of travel to the Central Traffic District it was possible to illustrate in diagrammatic form the changes in mode and purpose of trips as distance from the central area increased. The varied nature of trips between suburban subsectors makes it inappropriate to deal with changes in the trip types by distance and a more general summary of movement is essential.

Although the Central Traffic District stands out as the greatest single traffic focus within the city, and exerts a centripetal force in the morning and a centrifugal force in the evening, more than half the daily trips performed in Christchurch neither originate nor terminate within the District. Approximately 194,000 internal person trips occur daily between suburban subsectors, although many of them pass through the central area (Table 7). This suburban travel reflects the suburban location of most of the population, a large proportion of primary and secondary schools, many of the city's industrial plants, all the local shopping centres, and a variety of social and recreational land uses, the sum total of which exerts a profound influence on the movement of people within the city.

The congestion of the Central Traffic District during rush hours, and the general friction of movement within the Belt Cordon Line caused by heavy traffic use, encourage intersuburban traffic to avoid the central area wherever possible. The result is that 46 per cent of suburban trips do not cross the Belt Cordon Line. However the gravitational force exerted by the retail-industrial district about the railway and in Sydenham counteracts this desire to bypass the area. This counter attraction adds considerably to the amount of traffic using the inner city area and accentuates the problems of congestion and parking that occur in the Central Traffic District.

Many suburban trips are for short distances and are made for purposes such as visiting friends, or calling at local stores, post offices or banks.[8] Compared to suburban subsectors close to the Central Traffic District, outer suburban areas such as New Brighton, Hornby and Sumner have less incentive for regular travel to the central area, and greater dependence on local shopping services and work places. The patterns of movement resulting from increased use of local facilities appear to be quite different from the pattern of trips to the Central Traffic District.

MODE

The relative importance of modes of travel between suburban subsectors differs from their ranking in terms of movement to the Central Traffic District (Table 10). The most significant change is seen in the increased use of cycles: the number of cycle trips exceeds car trips by 14,000. However, cars often carry more than a driver and the combined total of car drivers and car

[8] Many short distance movements were excluded from the surveys by the definition of a trip as a journey of half a mile or more and involving a movement from one subsector to another.

TABLE 10

TRAVEL BETWEEN SUBURBAN SUBSECTORS*, BY MODE FOR 12 HOUR PERIOD : 1959

Mode of Travel	*Number of Person Trips*	
Car Drivers	57,857	
Car Passengers	18,487	76,344
Cyclists (Motor, Power & Pedal)		72,058
Pedestrians		22,573
Bus Passengers		19,950
Trade Vehicle Passengers ..		2,031
Taxi Passengers		940
Train Passengers		343
TOTAL		194,239

* Excludes travel to and from the Central Traffic District.

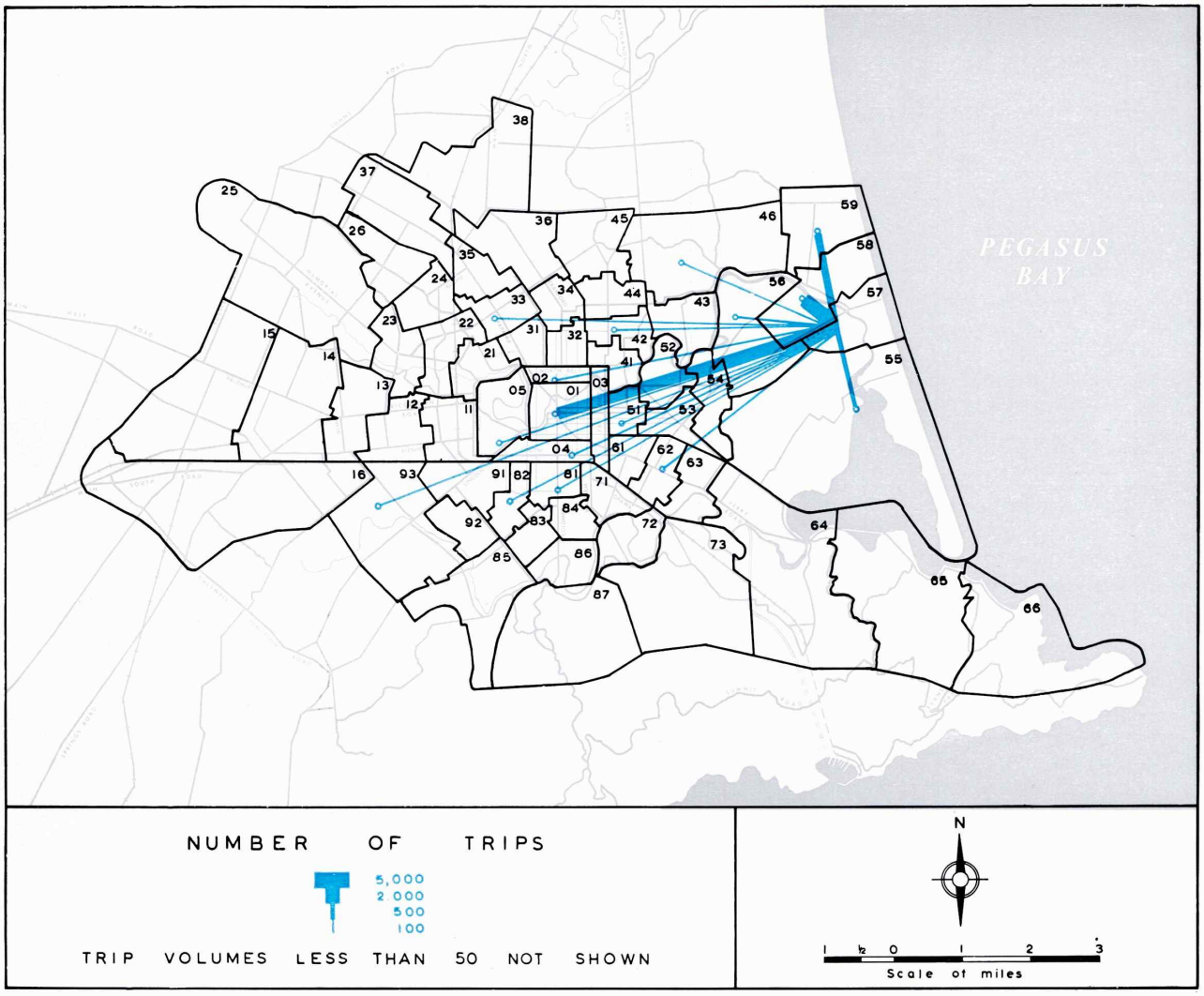


Fig. 37. Desire lines for total person trips to and from New Brighton, 1959. Travel between subsector 57 and all other subsectors for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

passengers was found to slightly exceed the number of cycle trips. Pedestrian trips are also significant, ranking slightly above car passengers and bus passengers.

The dominance of cycles and pedestrians in the pattern indicates that the bulk of intersubsector movement is of short trips and this is especially true of pedestrian trips. The trip patterns about New Brighton appear to be typical of inter-subsector travel as a whole (Fig. 37). In particular, this area illustrates the importance of each mode of travel and the effect of distance on the selection of trip modes. Walking and cycling, for instance, appear significant for trips between subsectors in New Brighton, North Brighton and South Brighton, while cars and buses handle most of the trips between New Brighton on the one hand and on the other, Linwood, Waltham, Sydenham, the Central Traffic District, or more distant areas of potential attraction.

TABLE 11

TRAVEL BETWEEN SUBURBAN SUBSECTORS, BY PURPOSE FOR 12 HOUR PERIOD: 1959

FROM \ TO	*Work*	*School*	*Shopping*	*Personal Business*	*Social Recreational*	*Meal**	*Serve Passengers*	*Change Travel Mode*	*Home*	*Total*
Work	6,925	58	245	557	276	342	130	305	33,511	42,349
School ..	237	58	69	344	423	42	28	—	29,196	30,397
Shopping ..	159	—	180	92	87	58	31	87	5,591	6,285
Private Business	252	—	119	1,146	254	60	86	114	7,508	9,519
Social-Recreational	86	—	144	114	495	28	114	56	8,276	9,313
Meal* ..	235	—	—	29	31	31	—	—	308	634
Serve Passenger	114	28	30	—	—	—	208	31	1,760	2,171
Change Travel Mode	56	—	—	—	—	—	29	—	638	723
Home ..	37,333	30,420	5,099	9,003	7,965	501	1,765	719	23	92,848
TOTAL ..	45,397	30,564	5,886	11,285	9,531	1,062	2,391	1,312	86,811	194,239

* The purpose was largely to and from lunch.

TRAFFIC NODES

Because of the large number of possible trip combinations for suburban origins and destinations, there are few important traffic nodes in the suburban subsectors and their location can be adequately illustrated by the pattern of trip desire lines for cars and taxis (Fig. 31). The principal centres of attraction occur along two main axes; firstly, in the vicinity of Sydenham and the southern part of Colombo Street, and secondly, along the main western routes. The maps of desire lines highlight the interdependence of certain suburbs and help to delimit four areal patterns, each of different traffic densities (Figs. 31, 32, 36, 38 and 39).

The first of the patterns is the Sydenham–Moorhouse Avenue area which attracts person and vehicle trips from all over the Internal Area but especially exerts a strong influence on suburbs to the south and east. The second is the Riccarton Road complex in which a ribbon pattern of interdependence extends in an east-west direction along the main western and southern road outlets. The third pattern is the irregular, light network between suburbs in the north and west of the city with a tendency for movement to concentrate on Papanui and St. Albans. Finally there is New Brighton where the light network is oriented in a north-south direction paralleling the shoreline and with only minor links to other suburban areas.

PURPOSE

Movements between suburban subsectors can be classified according to the same purposes as was done for travel to the Central Traffic District. There is however, a different emphasis on the nature of trips undertaken and this indicates more diversity of purpose for suburban trips.

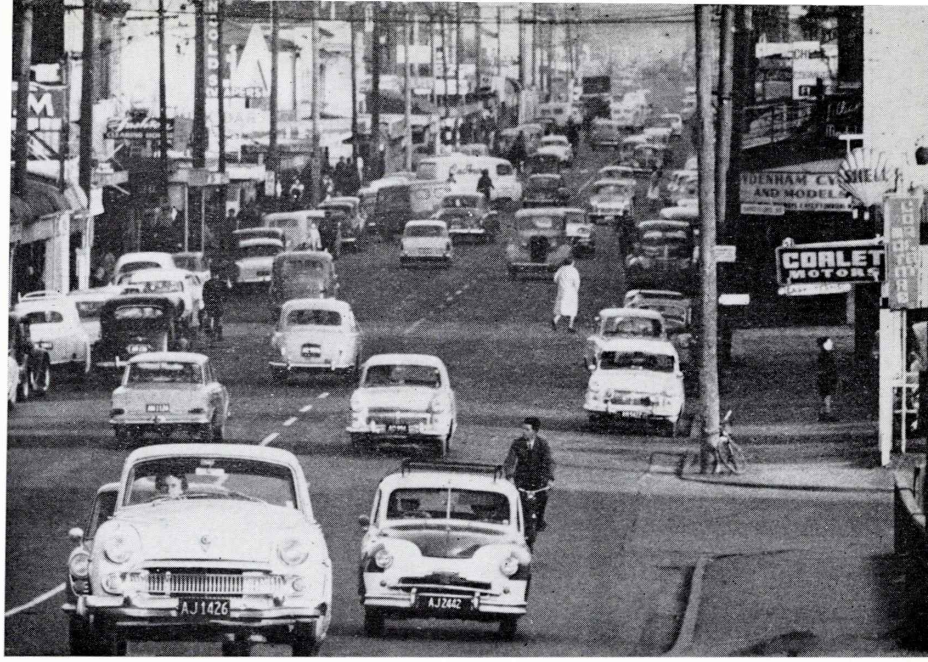
Apart from home trips and as with travel to the centre, the journey to work trips are clearly dominant and this firmly establishes the household and the work place as the principal generators of travel (Table 11). This is however the limit of the similarity to trips to the Central Traffic District.

Private business and shopping generate only six per cent and three per cent respectively of all intersuburban trips. The paucity of shopping trips may be explained by two main factors; firstly by the nature of the definition of a trip for the purposes of the surveys as a journey of half a mile or more and involving a movement from one subsector to another, and secondly by poor reporting of this type of local trip by persons interviewed. Nevertheless, the relative importance of shopping in the city centre and the suburbs is quite different.

School trips are particularly important within the total pattern of suburban trips, ranking third in terms of generating power. Most of Christchurch's schools are located in relation to population. Each tends to draw its pupils from the sur-

Plate XVIII

Suburban Traffic



Sydenham retail and industrial node

Trips to school

Shopping trips are mainly by car

TABLE 12

TRAVEL BETWEEN SUBURBAN SUBSECTORS, BY MODE* AND PURPOSE FOR 12 HOUR PERIOD: 1959

PURPOSE \ MODE	*Car Drivers*	*Car Passengers*	*Motor, Power and Pedal Cyclists*	*Bus Passengers*	*Pedestrians*	*Other*	*Total*
Work	*21,990*	2,774	15,263	2,796	1,585	989	45,397
School	145	1,459	*17,027*	3,923	8,010	—	30,564
Shopping	*2,104*	694	1,670	223	1,021	174	5,886
Private Business	*4,817*	2,264	1,737	1,233	594	640	11,285
Social-Recreational	*3,015*	2,557	1,206	2,061	519	173	9,531
Meal†	*472*	243	100	189	29	29	1,062
Serve Passenger	*2,128*	143	92	28	—	—	2,391
Change Travel Mode	*660*	56	336	178	—	82	1,312
Home	22,526	8,297	*34,627*	9,319	10,815	1,227	86,811
TOTAL	57,857	18,487	72,058	19,950	22,573	3,314	194,239

* Dominant Mode for each purpose is in italics.
† The purpose was largely to lunch.

rounding area and this, in combination with the requirement of large blocks of land for both buildings and playing fields, favours locations outside the high-rent central area and situations that minimise travel for the pupils.

The time pattern of school trips also differs slightly from the common time series for the city as a whole, especially in relation to the 'from school' peak. Whereas the normal evening peak occurs between 4.30 p.m. and 6.00 p.m., the school peak is reached between 3.30 p.m. and 4.30 p.m.

An interesting feature of travel between suburban subsectors is the relatively high proportion of social-recreational trips reported. Much of this travel is strictly social in the sense of morning coffee and afternoon tea visits by the womenfolk of the residential suburbs. Another factor is the predominance of open spaces and recreational areas in the suburbs and the relative lack of these features in the centre. The importance of this trip purpose undoubtedly varies throughout the week. The large number of clubs, playing fields, race tracks, parks, beaches, theatres and restaurants located in suburban areas generates a great deal of weekend traffic in particular.

The time pattern of social-recreational trips also varies from the typical daily pattern of movement. Trips for social-recreational purpose form peaks that are determined by social customs as well as by the starting times of theatres, cinemas, dances and sporting functions. On Saturdays when commercial establishments within the city are closed,[9] a number of nodes, of which Hagley and Lancaster Parks are two, replace the one predominant weekday focus of the Central Traffic District. During summer local beaches are important traffic foci.

PURPOSE AND MODE

Several purposes and modes of travel appear to be directly related (Table 12). For example, work trips are largely by private car, the cycle ranking second in importance. Trips for private business and to serve passengers are again largely carried out by car, as are the bulk of shopping trips. This reflects the paucity of intersuburban bus routes because of the economic difficulty of providing them in residential suburbs of low density. School trips however are usually performed by cycle or by walking and each of these modes far outnumbers the total of bus trips.

It is also possible to determine which is the major purpose for each mode of travel apart from the trip to home which is of prime importance for

[9] Except for the New Brighton shopping area which in general closes all day Wednesday and opens all day Saturday, including late evening (to 9 p.m.).

each mode. For example, the principal trips undertaken by car drivers and passengers are to work. Cycle trips are evenly divided between work and school trips, with the latter of slightly more significance. The cycle is little used for shopping, private business and social-recreational trips in the suburbs. School journeys provide the largest single purpose for bus trips, but this mode is also frequently used for work trips and for social-recreational trips. The most important pedestrian trips are to school. There is then, an important difference of purpose between pedestrian trips to the centre, where they are mainly work trips, and trips by the same mode within the suburbs.

The variations of travel modes for different purposes is important both in regard to the type of vehicles predominating throughout the day and in relation to parking demands. Cycles and cars predominate in the morning peak hours and this mixture is further complicated by the extra buses used to carry passengers to work. The private car and the pedestrian remain in evidence throughout the day. Bus trips however, decline in the off-peak periods. Cycles are important in the total pattern of movement at lunch time and again in mid-afternoon when trips from school occur. Cars predominate in the evening peak: cycles and buses are of less importance but of sufficient magnitude to add severely to traffic congestion.

PARKING

The demand for parking and the use of reserved space for buses vary throughout the day. The heaviest demand on parking space occurs immediately prior to the start of the working day and lightest demand occurs immediately after the evening rush hour. Because cars play such an important part throughout the day performing most of the trips for shopping, private business, firm's business and social-recreational purposes, there is a constant demand for parking spaces for these users. The best allocation of space for short-term and long-term parkers, and for use by buses and taxis, is a problem at present facing the city's traffic engineers and land use planners. Except for areas such as Sydenham, Riccarton, and New Brighton however, the problems associated with parking and with hourly variations of traffic are not generally as acute in the suburbs as they are in the Central Traffic District.

EXTERNAL TRAVEL

On an average 12 hour weekday in 1959 journeys between the Internal Area and the External Area accounted for approximately 10 per cent of personal movements within the Internal Area.[10] Approximately one third of those trips were oriented towards the Central Traffic District, the remaining two thirds being distributed among a variety of suburban destinations (Table 7). The principal originators of traffic crossing the External Cordon Line include both suburban outliers of Christchurch and some of the small towns of the Canterbury Plains, such as Rangiora, Kaiapoi and Darfield.

LYTTELTON TRAFFIC

Lyttelton at the time of the 1959 survey had poor road connections with Christchurch and consequently the railways handled the bulk of both personal and freight movement between the city and the port. With the advent of the road tunnel however, the relative roles of road and rail may substantially alter.

The travel surveys showed that, on an average 12 hour weekday, 2,622 people left Lyttelton with destinations within or beyond the Internal Area of Christchurch, and, of these, 660 were destined for the Central Traffic District. The distribution by mode of travel is shown in Table 13.

TABLE 13

TRAVEL FROM LYTTELTON, BY MODE FOR 12 HOUR PERIOD : 1959

Mode	*Person Trips*	*Trips to C.T.D.**
Car Drivers ..	327	70
Train Passengers	2,000	522
Other Modes ..	295	68
TOTAL ..	2,622	660

* Central Traffic District.

[10] Trips between external localities that cross cordon lines represent a negligible number of trips within the present pattern of movement. For further details of external movements see Table 54 in Appendix H.

TABLE 14

INTERNAL-EXTERNAL TRAVEL, BY MODE FOR 12 HOUR PERIOD: 1959

MODE	NUMBER OF PERSON TRIPS		
	To or from Central Traffic District	*To or from other Internal Subsectors*	*Total*
Car Drivers	4,614	8,948	13,562
Car Passengers	3,906	6,862	10,768
Train Passengers	1,162	3,396	4,558
Bus Passengers	1,624	1,402	3,026
Trade Vehicle Passengers ..	854	1,614	2,468
TOTAL	12,160	22,222	34,382

In addition, there were 112 trade vehicles moving out from Lyttelton and 40 of them were destined for the Central Traffic District.

The trips involve many purposes. Some are commuter traffic, others are concerned with servicing the area (from outside), are generated by local employment, or are associated with the interisland ferry. Because of the relative isolation of Lyttelton it is more self-supporting than other adjacent localities and, as a consequence, is not as heavily dependent on the Internal Area of Christchurch either for work places or shopping. Ease of movement generated by the tunnel road could both increase interaction—especially by increasing trade vehicle movements—and help Lyttelton to develop a greater range of service functions in order to cater for potential population growth as its value as a residential outlier increases.

Despite the large element of independence in Lyttelton's functions, the principal purposes of trips to Christchurch are related to business, shopping and social activities. Trips undertaken for such purposes cover almost 50 per cent of the total movement. The remainder is commuter traffic, largely to work, but with some movements to school.

OTHER TRIPS

External localities also contributing large numbers of people to the external-internal movement are Halswell and Belfast; others contributing significant numbers of people include Harewood, Burwood, Marshland, Templeton, Kaiapoi and Rangiora (Table 55 in Appendix H). These are expanding satellite centres subject to strict zoning regulations such as minimum sizes for subdivision. For the most part they are still surrounded by rural-urban fringe land of market gardens, orchards and town supply dairying. Successive advances of the city into the fringe, prior to zoning, increased the generating capacity of each centre, but on the whole, their future appears to depend on the extent of possible releases of land for urban development and the amount of consolidation of land subdivided before restrictions were imposed.

DIRECTION AND MODE

Approximately one third of the trips crossing the External Cordon Line originate in or are destined for the Central Traffic District. Apart from this movement, the principal foci are Riccarton, Hornby, Papanui and Sydenham.

An interesting picture is presented by the analysis of travel mode, with probably the most significant feature being the importance of car passengers within the total pattern (Table 14). Although there is little evidence of the 'park and ride' method[11] there is evidence, in the large

[11] 'Park and ride' method refers to moving by car, parking, and and transferring to other modes of transport, for example, buses (see Chapter Six).

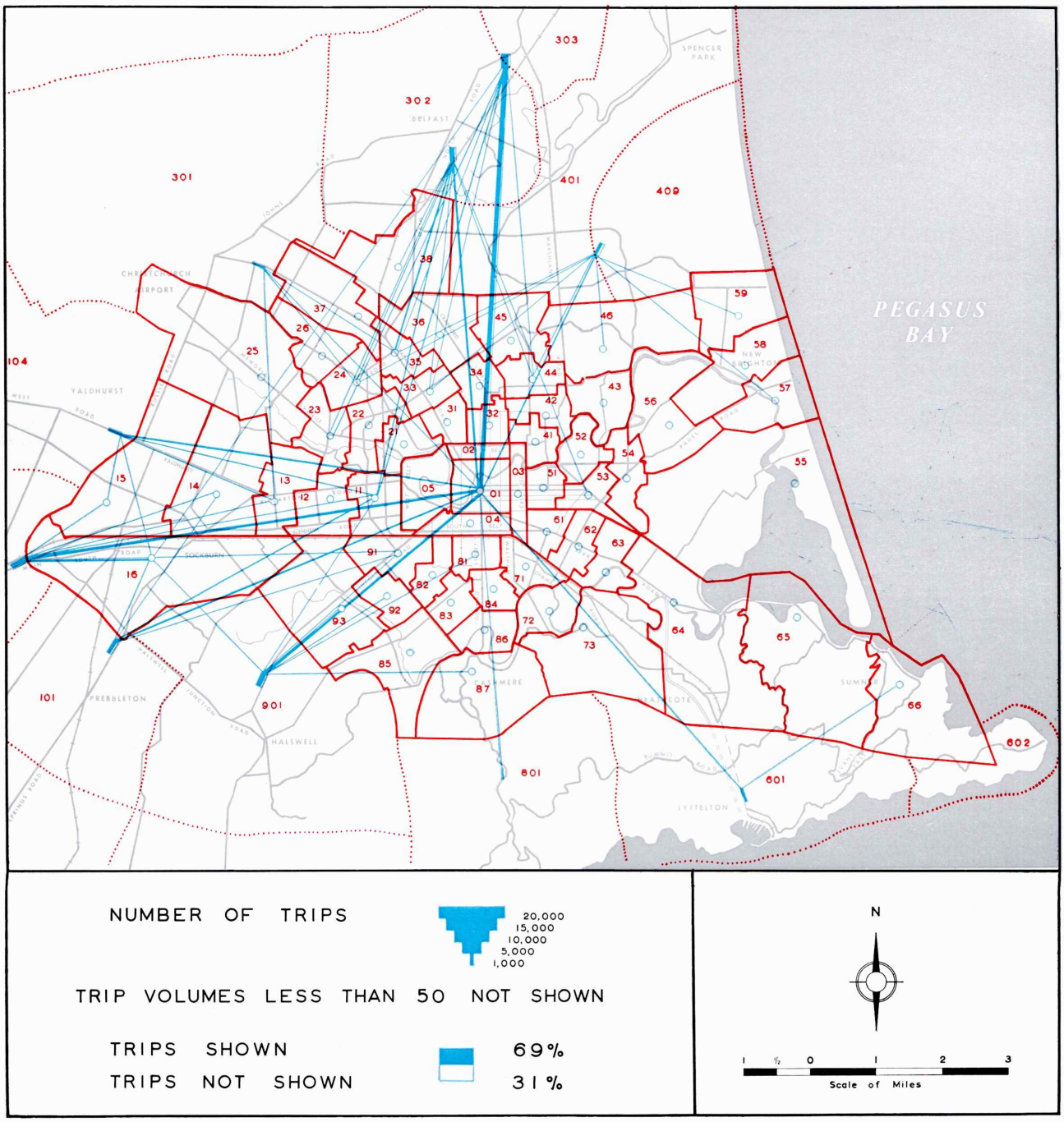


Fig. 38. Desire lines for private cars and taxis between internal subsectors and external area, 1959. Travel for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

number of car passengers, of the pooling of vehicular resources in an attempt to economise on travel expenses and minimise parking problems. Part of the total of car passengers may also be explained by family journeys of rural dwellers.

Motor cars, including both driver and passengers, provide the most important mode of travel, accounting for approximately two thirds of all personal movements. The direction and force of these movements can be shown by means of

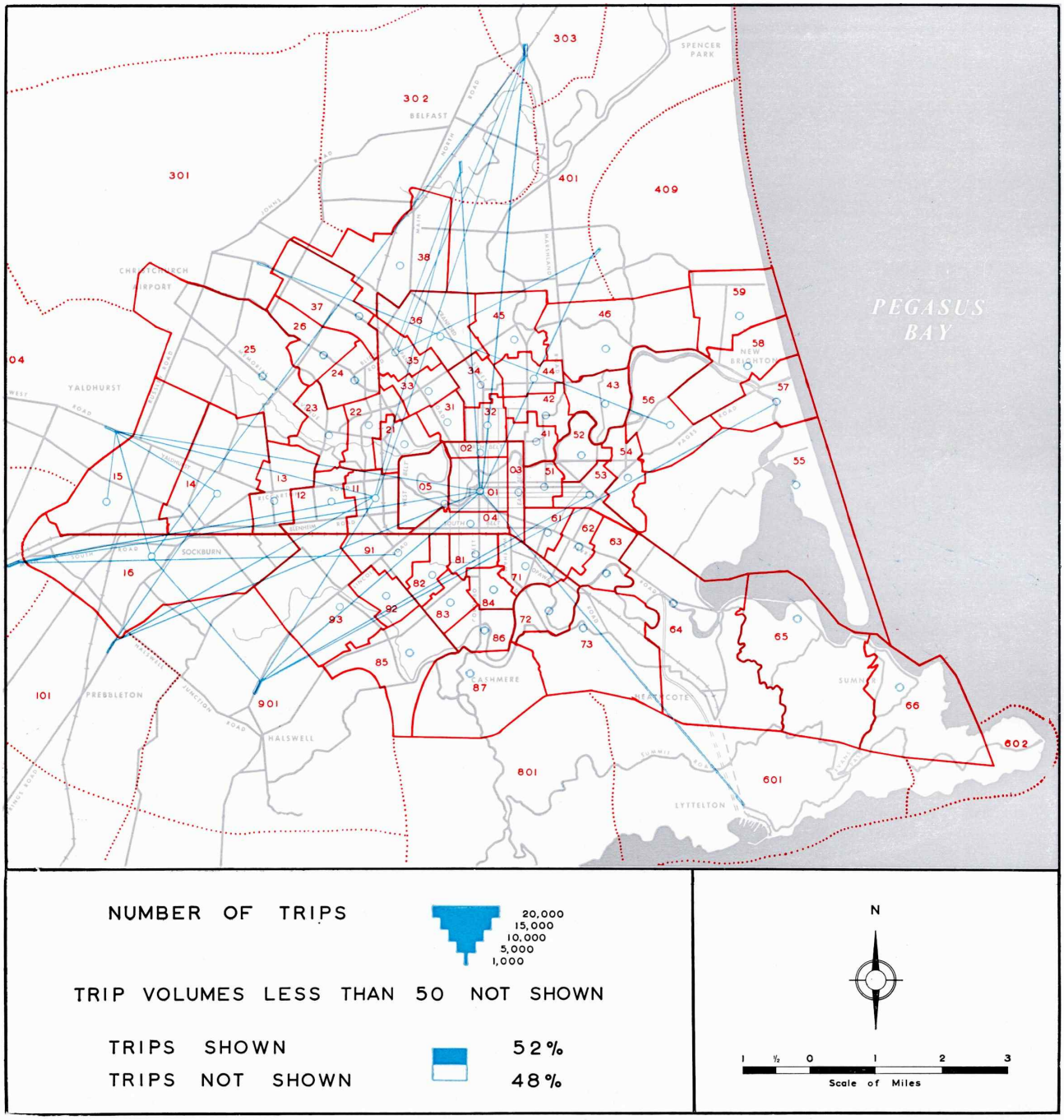


Fig. 39. Desire lines for trade vehicles between internal subsectors and external area, 1959. Travel for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

desire lines; the general pattern of trip desires emphasises the attracting power of the Central Traffic District, principal interactions including those between the Central Traffic District and traffic along the main north road or passing through Halswell or Templeton (Fig. 38).

Trade vehicles comprise approximately one third of the total internal-external vehicular movement and, for the most part, the trade vehicles are delivery vans and light trucks used to carry horticultural produce to the city markets. The Central Traffic District is the only signi-

TABLE 15

TRAVEL FROM THE EXTERNAL AREA TO THE CENTRAL TRAFFIC DISTRICT*, BY MODE AND PURPOSE FOR 12 HOUR PERIOD: 1959

TRIP PURPOSE	MODE OF TRIP (NUMBER)			
	Car Drivers	*Bus and Train Passengers*	*Other*	*Total*
Work	327	604	180	1,111
Business	1,626	249	1,800	3,675
School	—	—	—	—
Work after Lunch ..	—	—	—	—
Shopping	289	479	345	1,113
Social-Recreational ..	201	—	257	458
Home	Insignificant†	—	—	—
TOTAL ..	2,443	1,332	2,582	6,357

* Motor, Power and Pedal Cycles not sampled.
† 'Home' is the major purpose of trips *from* the Central Traffic District *to* the External Area.

ficant individual destination within the Internal Area (Fig. 39).

PURPOSE

The hierarchy of trip purposes to the Central Traffic District is basically the same as that for internal movements, with trips to work and on firm's business predominating (Table 15). This is further emphasised by the relatively large number of trade vehicles in the total vehicular traffic. Of all vehicles crossing the External Cordon Line approximately 30 per cent come into this category. Shopping and social-recreational trips to the Central Traffic District are few in number, with shopping generally being the more important force.

TOTAL TRAVEL

The outstanding features of the travel and traffic surveys and the ways in which people and vehicles move on an average weekday have been described. In developing a transportation study an understanding of these patterns is an essential step.

During the 12 hours from 6.30 a.m. to 6.30 p.m. on an average weekday in 1959 some 355,000 person trips were made and some 163,000 vehicle trips by cars and trade vehicles were counted. Of total trips most were of short distances; 41 per cent were made by car, one third by cycle and less than one fifth by public transport. Over half of all travel was directly associated with work, and trips to school were next in importance.

The trips by persons and vehicles follow a regular time sequence through the day and the repetitive character permits the prediction of peak periods of travel from the analysis of data for an average weekday. The directions of travel show the dominance of a single focus, namely the Central Traffic District comprising as it does a large part of the central business district and adjacent streets for parking. Within the suburban subsectors there are a multiplicity of nodes that are individually of less significance. Travel through the Internal Area from one external locality to another is of minor significance and amounts to only three per cent of all traffic crossing the External Cordon Line. This very low percentage is a result of the outstanding primacy of Christchurch in the urban hierarchy of Canterbury: that is traffic either comes to or goes from Christchurch and very little simply passes through from one place to another.

The descriptive devices used in this chapter show the pattern of travel as it existed in 1959. It is realised that the construction of new facilities,

for example a road tunnel, affect not only the routes taken but also the choice of destination and possibly the mode of travel. As was shown in Chapter Two the type and intensity of land use is influenced by the transportation system. New facilities in a transportation system may therefore produce changes in travel patterns and urban structure. However, travel is continually being adjusted to the urban structure which itself is slow to change.

TRIP GENERATION

Trips are made for particular purposes. In all cases they are made to attain a particular desire either in terms of monetary rewards, such as a journey to work, or non-monetary rewards, such as travelling to a cinema to see a film. These rewarding activities generate travel and an analysis of them leads to an understanding of travel patterns. The success of predictions of traffic rests upon the ability to understand, account for, and successfully project into the future the influence of the rewarding activities that generate present movement.

Not all trips are made for the same purpose and by the same mode of travel. Some areas have a surplus of, or specialise in a particular activity, others are deficient; consequently there is an incentive for movement between areas. Within a city this movement revolves about the fact that few people can live and work in the same place. Thus there is constant movement between the home and other parts of the city, where work places, open spaces, shopping centres, recreational and other facilities occur.

It is obvious that a large number of measures of land use come into play in accounting for the generation of trips and, theoretically, all of influence should be used in explaining present patterns of movement and, hence, in forecasting future travel. In practice however, this is neither necessary nor possible and therefore, the various characteristics are assessed in order to select those that are most significant and can be handled by the means that are available. This section is primarily concerned with the selection, from the wide range available, of those characteristics that were found to be most significant in explaining present travel and, at the same time, useful in estimating future travel. Once having selected the characteristics, the next step is the derivation of a series of mathematical formulae and other relationships that satisfactorily explain 1959 travel in terms of the chosen characteristics; this step is discussed in Chapter Five.

CHARACTERISTICS

The procedure adopted to isolate the significant variables consisted of an exhaustive testing of numerous measures of land use and other characteristics in order to achieve the highest level of explanation of present day personal and vehicle movement in Christchurch. Refinement of the initial consideration of the large number of possible characteristics, resulted in 15 which appeared most useful in explaining trip patterns. These were drawn from a wide range including, for example, population and building densities of various kinds, valuation classes, types of employment, age structure, components of distance. Each characteristic was related to the total trip pattern by simple graphical correlation techniques in order to eliminate the less significant and one or other of closely related pairs of characteristics. The remaining variables were submitted to further analysis by graphical regression techniques and, for some variables, statistical testing was carried out. The limitations of available sources of machines, manpower, and time enforced a restriction on the number of variables that could be used and the type of formulae that could be developed. By this procedure the characteristics of subsectors were reduced to four, namely:

Average valuation of residential improvements	V
Total employment	E
Commercial employment in defined shopping centres	S
Distance of assumed traffic centroid from the centre of the city (Cathedral Square)	D

There was of course a hidden characteristic used,

number of households (H), because the unit area in analysis, the subsector, was defined in terms of approximately 1,000 households.[12]

AVERAGE VALUATION

Average valuation of residential improvements was chosen as the most satisfactory indicator of the generating power of residential land. One of the significant findings of the analysis was that high valuation areas tended to contribute more workers to the city centre than low valuation areas. It was also found that workers in high valuation areas were more likely to drive a car and this correlated closely with the association of high residential valuations and high indices of car ownership in the northwestern and southern subsectors of the city.

It was also felt that, as zoning is an accepted planning method in the Christchurch area and development of residential land can therefore be controlled by excluding undesirable uses, the variations of valuation over time could be more accurately predicted than other aspects of residential land. Given the assumption that factors influencing present traffic would be largely responsible for variations in 1980 traffic, it appeared reasonable to accept valuation as a significant independent variable.

TOTAL EMPLOYMENT

Total employment is an expression of the economic working of the city and is therefore important in explaining traffic flows. Selection of this variable is in some ways representative of journeys to work in the total trip patterns. The assumption underlying the choice of employment is that most residents will travel outside their own subsector to obtain employment. This is axiomatic in a modern city, as is the statement that the larger the employment opportunities in an area, the greater is its potential generating power. This relationship is observed frequently in Christchurch where many suburbs are almost entirely residential and where the daily outward movement from these subsectors towards areas of employment is considerable.

Employment is a variable that is more pertinent to an explanation of some purposes than others. For instance it is particularly useful in dealing with work trips and trade vehicle movements. The degree of correlation between employment and the number of trade vehicle trips indicates that the location and volume of employment is a significant factor in explaining trips undertaken by these vehicles. A similar high degree of correlation exists between employment and work trips; the employment variable becomes important therefore in both personal and vehicular movement.

COMMERCIAL EMPLOYMENT

Commercial employment appears to warrant selection in any formula explaining traffic movement. Its great generating power was observed especially in relation to movements into the Central Traffic District which was the destination of nearly half of the daily movement. The generating power of suburban shopping centres was similarly observed. Employment appears to be a more satisfactory measure of the strength of commercial activity than the land area of shops or the number of shops. An alternative method is to measure floor space devoted to commercial activities but for Christchurch the two criteria of numbers employed and floor space give much the same relationship. Another possible measure is the value of sales but these figures were not available. The final selection of employment as the measure was based on the availability of suitable data from the Department of Labour.

Commercial employment, as was true of total employment, is more satisfactory in explaining specific purposes rather than total trips. In particular it helps explain the movement of people for shopping purposes but it is also useful in assessing the potential volume of business and work trips which may be directed towards any particular subsector. Its importance in relation to movements to and from the Central Traffic District makes it imperative to include this variable in any formula for the prediction of trip generation.

[12] A household unit is defined as a group of rooms or a single room, occupied or intended for occupancy as separate living quarters, by a family or other group of persons living together or by a person living alone.

DISTANCE

Distance is a factor that not only influences the volume of trips undertaken but is also significant in determining the mode of travel and the purpose of movement. Its effect was found to be usually inverse: for example, as distance from the Central Traffic District increased the likelihood of a subsector or locality contributing workers to that centre was reduced (Fig. 40). Thus the local

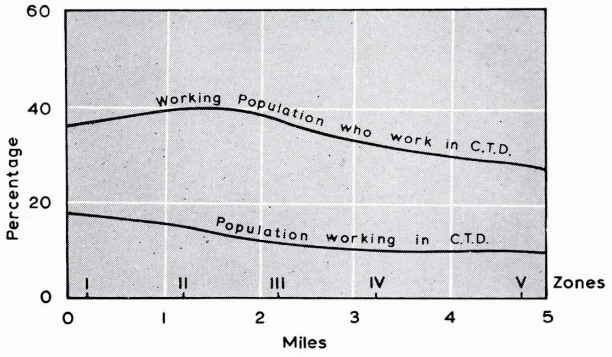


Fig. 40. DISTANCE AND THE POPULATION WORKING IN THE CENTRAL TRAFFIC DISTRICT, 1959. The population working in the Central Traffic District from each distance zone is expressed in two ways—as percentage of total working population of that zone (upper line), and as percentage of total population of that zone (lower line).

work place and suburban shopping centre would appear to become larger traffic generators as the urban area expands, and much of this importance is based on distance—or, in other terms, decreasing accessibility—to the Central Traffic District.

Despite growing consciousness of the scope and advantages of urban renewal, the character of urban expansion is centrifugal. As the urban fringe advances into the countryside the characteristics of peripheral subsectors undergo change. As they become more developed with smaller residential sections and a higher density per acre of developed land, they change their nature and level as traffic generators. This is usually accompanied by changes in the modes of transport used in daily travel and by changes in the principal directions of movement. Other things being equal the effect of distance on the proportion of people driving cars was not of high significance and the 1959 surveys showed that any decrease in car drivers in relation to distance was offset by the increasing extent to which people travelled to work as car passengers. Distance appeared to have a direct effect on the relative use of other modes of travel and as predictions were intended to deal with modes as well as purposes, this variable could hardly be neglected.

CONCLUSION

Success in planning for the future largely depends on the ability to isolate present problems. Although conditions change over time, analysis of the present often brings out important features that may help to define and overcome problems of the future. This is particularly true of transportation in which the points of congestion, the barriers to through movement, and the availability of parking space are all problems of the present time and are magnified in importance as traffic volumes increase.

In making predictions of future travel, it is essential to know what generates movement in a city, in other words why trips are made. By careful analysis of 1959 travel and traffic in Christchurch, it was possible to reduce the wide range of possible variables that might account for the 1959 patterns to four characteristics which were shown by various tests to be of major significance. The average valuation of residential improvements was chosen as the most satisfactory indicator of the generating power of residential land; total employment measured the economic working of the city; commercial employment in defined shopping centres was important in explaining the attraction of the Central Traffic District, as well as generating trips in suburban subsectors; and distance had a direct effect on the relative use of modes of travel.

In Chapter Five these variables are used in the development of formulae and other relationships; that is, 1959 travel and traffic are related to 1959 land use, employment and other characteristics. By predicting the value of these variables the same formulae or graphs can be used to forecast 1980 travel. But before this step can be taken, the growth of the particular variables and related items has to be estimated and to this the next chapter must turn.

CHAPTER FOUR

Population and Economic Growth

IN BROAD TERMS the movements of people and vehicles in 1980 have been forecast by considering the situation in 1959 and making allowances for the anticipated growth of the study area and other changes which are expected to occur in the intervening period. Many serious difficulties beset the planner making such forecasts and it is worth while to review these briefly before considering the detailed studies which have been made.

MAKING FORECASTS

A man rides a cycle, drives a car or truck, or rides in a bus, because he has a purpose to serve and that particular vehicle is available to him. Any estimate of future travel generation must be viewed against the twin backgrounds of need and opportunity. The need for travel and transport arises from the location of homes, work places, shops, amusement places and the like. The future need will depend upon how a town grows and hence upon technical developments as well as the extent to which the local economy thrives or languishes. It is very difficult to predict such matters and the estimates for land use and employment in 1980 rely upon the experience of recent use and what are thought to be reasonable aspirations for the future. These estimates may prove wrong, for it would be easy to assume an amount of building development, or redevelopment, greater or less than the resources of the community will permit.

In like manner it is necessary to assume that all forms of transport will remain readily available in the future, that no newer, cheaper forms of transport will be devised, and that the relative advantages of economy and convenience of different modes of transport will be substantially as they are now. New Zealand cities do not at present have traffic congestion comparable with that in some large American and European cities but it is important to remember the pressure which exists overseas to develop new and more efficient means of mass transportation. It is conceivable that successful experiments overseas might, within the forecast period, lead to changes in the modes of New Zealand travel. In the meantime it has been assumed for the purpose of this study that the growth of the economy will allow a widening of the ownership of private transport, and that the latter offers such advantages of time and convenience that it will continue to increase in importance at the relative expense of publicly operated transport. This last matter is so important that it is considered again in Chapter Six in relation to the provision of car parks.

A theoretical difficulty occurs immediately. The changes which occur in the region can be thought of as the uncoordinated responses by individual persons to the interplay of economic, social and physical factors, or as changes made in conformity with a plan prepared in the interests of the community as a whole. Alternatively it may be supposed that neither private ambition nor the public weal will be dominant and that flexible planning will occur. It is impossible for a New Zealand community to envisage a state of either unfettered private planning by individual citizens or of complete subservience to the planning of an authority, but between these wide extremes a great range of compromises is possible. Any forecast of land use therefore must be affected by any changes in the balance which now exists between communal and personal decision, and in this connection two points are pertinent to this enquiry. The first is that recent history is one of increasing encroachment by authority upon the fields of private decision. And secondly, the present policy of Town Planning, that is the very

existence of Town Planning in the communities, suggests a belief that a planned community will be more efficient and pleasant than an unplanned one. On the other hand planning must always be based on research, which is often expensive, to determine the working of physical, economic and social factors. The form of planning by committees and by widespread public consultation attempts to ensure that public opinion is well informed and that planners are in touch with public demands.

An increasing need to travel results from the increasing perimeters of our towns. It is convenient and pleasant, in many respects, to build new living areas more spaciously as outer suburbs and in the short term it is economic to build on new sites, leaving the older central buildings for such residual value as they may hold for industrial or commercial users. Not only is there an apparent initial saving in construction costs, but other economic factors encourage such development. The direct cost to the householder of a new suburban house is at present less than the direct cost to him of a newly built flat, terrace house, or other more compact central dwelling. What the individual gains in amenity and saves in house-owning costs, is partly offset by other losses of amenity and by hidden higher costs to the community for services of all kinds.

The relevance of this to the present study lies in the fact that advances in building technology could possibly reduce central redevelopment costs and so change the balance of economic advantage. Moreover, this is a field in which the community can make positive decisions. Changes in government policy regarding housing finance, or changes in rating, or in the assessment of tariffs for public services, could exert a powerful stimulus to central redevelopment and produce a somewhat different urban form for Christchurch than that assumed for the purpose of this travel study. At the present time however, there is little indication that such changes in policy will all occur within the next 20 years if at all.

The target year for making forecasts was set at 1980 but this year should not be taken too literally, for construction programmes may be hastened or slackened to keep in step with growth which will not be uniform in either time or space. Planning too far ahead would make the estimates of less accuracy and enlarge many imponderables, such as technical change, to great magnitude. Yet the target year had to be far enough ahead to permit the planning of a system and allow the bulk of its construction in order to handle traffic problems considerably greater than those of today. The year 1980 is thus in many ways a compromise. Nevertheless at various points in the present studies a look was cast further on in time but attention has been directed in this account only up to about 1980.

POPULATION

For the purpose of forecasting traffic in 1980 it is necessary to attempt to estimate the future population not only of Christchurch and its environs but also of more distant parts of the South Island which will in some measure contribute to the traffic of the urban area.

In 1858 the North Island of New Zealand had a larger population than the South Island but this position was reversed at the succeeding enumeration and the South Island maintained its pre-eminence through to the end of the century. At the census of 1901 however, the North Island regained the lead with 50.5 per cent of the total population of New Zealand and throughout this century it has steadily increased its proportion of the total population. During the present century therefore, the South Island has had a decreasing share of the country's population but this does not mean that the actual number of people has decreased. In fact there has been an absolute increase at every census but at a much slower rate than that of the North Island, and a continuation of this trend is expected into the future. The 1961 census recorded 730,199 persons in the South Island, representing 30 per cent of New Zealand's population.

For the purposes of estimating population in 1980 in relation to forecasting travel, the Canterbury Province was divided into two major parts (Fig. 41), viz.:

AREA A—Christchurch Urban Area (minus Lyttelton), Kaiapoi, Rangiora, Tuahiwi, Woodend, Brooklands, Spencerville (Spencer Park), Templeton, Prebbleton.

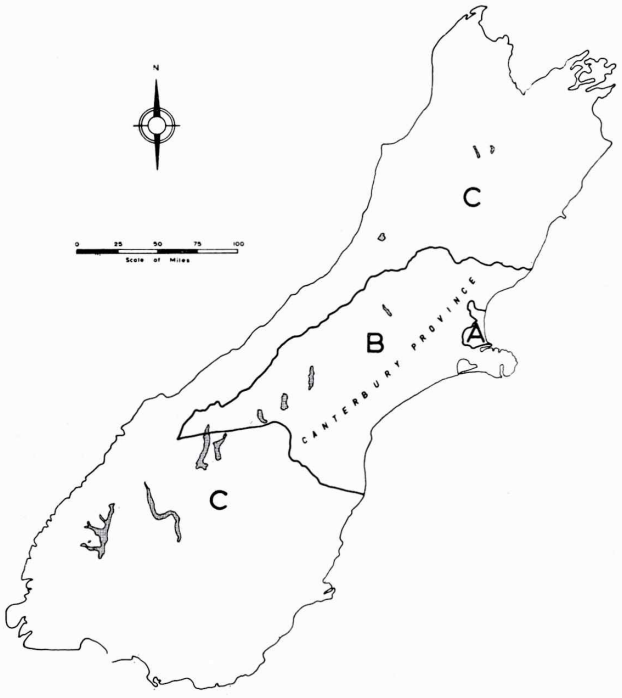


Fig. 41. POPULATION AREAS OF THE SOUTH ISLAND.

AREA B—remainder of Canterbury.

The population of each of these areas was projected in accordance with the trends exhibited by the population growth from 1926 through 1936 to 1959. In Area B, the remainder of Canterbury, the increase in population from 1926 to 1959 was almost completely within the six centres of Ashburton, Geraldine, Temuka, Timaru, Waimate and Lyttelton. The rural areas have shown very little increase in numbers of people, the growth in population being absorbed within the towns. The most spectacular increase has been in Area A and, in common with world-wide trends for growth in the larger urban areas, it is expected that the future increases in population will be greatest within this part of Canterbury.

For travel forecasting it was necessary to divide Area A into the Internal Area and the adjacent localities of the External Area. The estimates suggest a population of about 310,000 for the Internal Area with 35,000 people contained in the neighbouring localities, indicating that increasing proportions of the population will settle outside

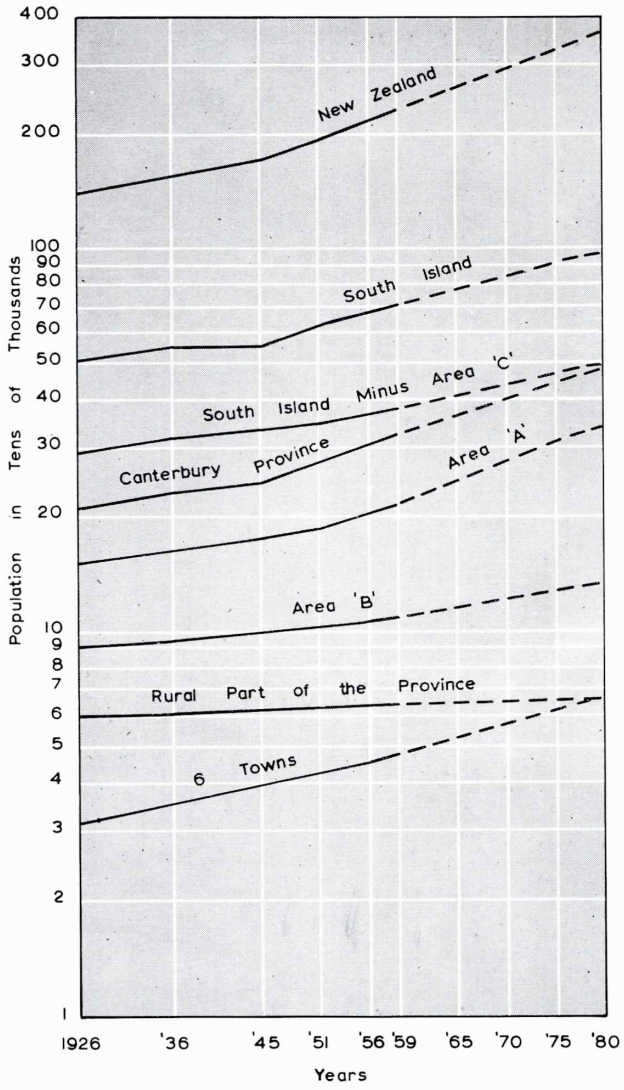


Fig. 42. POPULATION, 1926-1980: NEW ZEALAND, SOUTH ISLAND AND MAJOR AREAS. The '6 towns' are Ashburton, Geraldine, Temuka, Timaru, Waimate and Lyttelton.

Source: *Population Census, 1956*, Vol. 1, Wellington, 1957: 'Labour Force Projections and Revised Population Projections for New Zealand 1958-80', supplement to *Monthly Abstract of Statistics January, 1959*, Wellington, 1959: various special studies. *See Tables 46 and 47 in Appendix H for further details.*

the External Cordon Line as the Internal Area fills up. These trends and the resulting estimates are set out in Figure 42, and the estimates for

1980 in comparison to 1959 are shown in Tables 45 and 46 in Appendix H along with the growth factors thereby obtained.

LIVING AREAS

The Internal Area contains the major generating areas for traffic as here the great majority of the 1980 population will live. The estimation of future population within this area is complicated by the fact that, without detailed planning, control, and direction in residential building, it is not possible to estimate the actual amount of land that will be used for residential purposes or for other purposes which are normally permitted within a residential zone. In order that a reasonably accurate population forecast can be made for the traffic sectors and subsectors of the Internal Area, the concept of 'living areas' was introduced.

A living area may be conveniently defined as containing all those uses normally found in residential areas including those that are required to satisfy the everyday needs of the residential population, such as primary schools, small parks, churches and local shops. Excluded from the definition are 'non-living' uses which have wider regional significance or are shared by more than one part of the urban area, for example an industrial district, a secondary school, hospital, racecourse, golf course, airport, and cemetery. Within the living areas it was assumed that there was no vacant or farming land; in other words, that the living areas for 1980 represent the capacity of each part of the city when it is fully built upon for urban purposes.

For the external limit for the built-up area, the urban fence was used as this represents the proclaimed planning boundary of the Christchurch urban area and follows in general the External Cordon Line. It is estimated that this area is capable of containing the population of about 310,000 forecast for 1980, assuming the present living patterns. Each traffic subsector was considered separately and around the urban margins, where the urban fence and the External Cordon Line diverged, adjustments were made. Working from these assumptions it was possible to calculate the living area and the number of households[1] within each subsector (Table 47 in Appendix H).

By plotting the average number of households per acre of living area for each subsector in 1959 it was apparent that the inner areas had high densities (3.8 households per acre and over), that the high valuation subsectors had low densities (less than 3 households per acre) and that most of the remaining subsectors were within the medium densities (3 to 3.7 households per acre). By using these groups of subsectors and applying a common ratio of households per acre to the living area for 1980 within each group, it was possible to distribute the total number of households required for the predicted population. In this way the 87,280 households for the 310,000 people of 1980 were distributed among the subsectors which were, in turn, ranked according to the number of households in each subsector. In other words the 1980 population was distributed within the Internal Area on the assumption that the whole area was fully developed for urban purposes under subdivisional standards similar to those of 1959. Figure 43 shows the resulting pattern which is also the pattern of the more important generating areas of the future.

This map indicates the general distribution of population in terms of number of households for 1980 in comparison with 1959, for each subsector was defined so as to have approximately 1,000 households in 1959. A concentric pattern of change is apparent. Around the central area the number of households will tend to decline as the living area decreases with the invasion of new forms of land use such as manufacturing. The next zone will show slight increases while the outer zone around the margin of the city will increase by two or three times over 1959. While there will be this general concentric pattern of change the most striking growth will occur in the north-western suburbs.

VALUATION

The analysis of 1959 travel data showed that the average valuation of improvements (residential)

[1] A household unit is defined as a group of rooms or a single room, occupied or intended for occupancy as separate living quarters, by a family or other group of persons living together or by a person living alone.

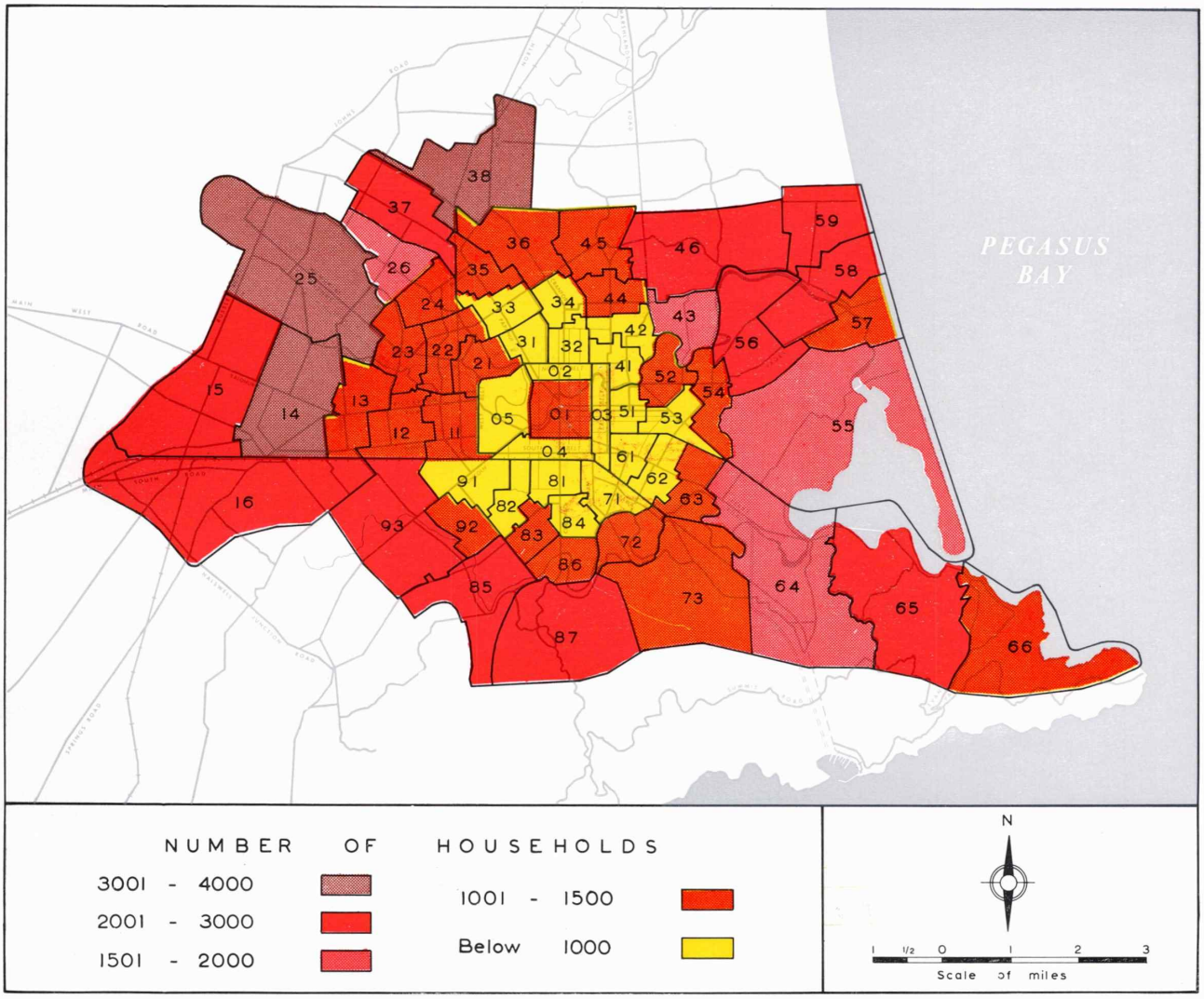


Fig. 43. POPULATION DISTRIBUTION, 1980: HOUSEHOLD UNITS. Comparison with the 1959 situation is readily made because each subsector was originally defined so as to contain approximately 1,000 households in 1959. *See Table 47 in Appendix H for details by subsector.*

was one characteristic which was significantly related to the movements of people and vehicles among the subsectors. This relationship might be explained in the sense that the higher the valuation of residential improvements, the greater is the economic prosperity of the people living in those areas and the more likely they are to own one or more cars and to use them more frequently. In other words valuation might be a fair indicator of areal variations in levels of income.

The average valuation of residential improvements within each subsector was calculated for 1959 and each division was ranked according to five valuation categories. No detailed projections were made for 1980 as it was assumed that the 1959 rank position will apply in 1980; changes from one category to another were made in a few cases where known developments were likely to alter significantly the position of a subsector. It is of course to be expected that the average valuation of residential improvements will increase but it is

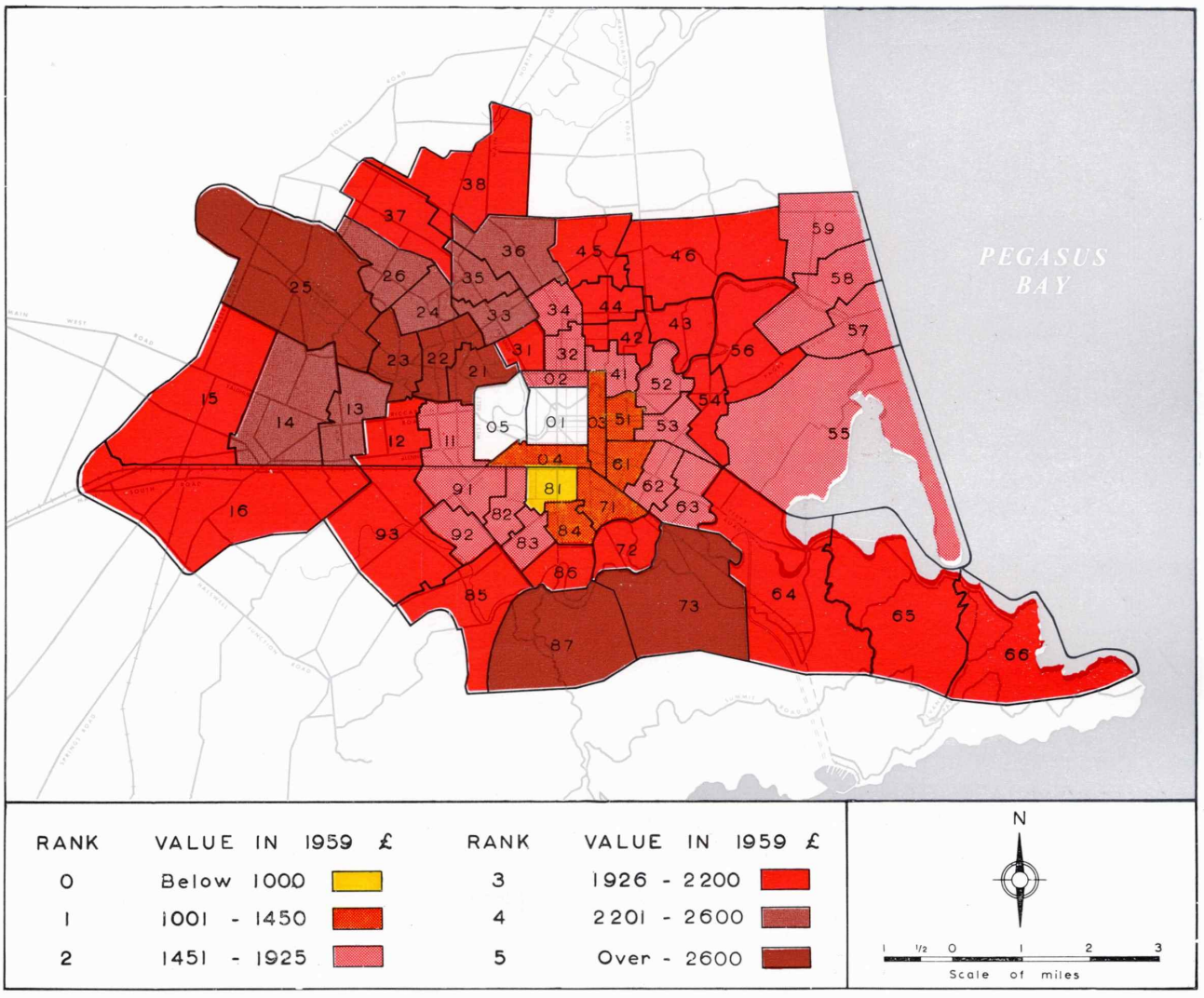


Fig. 44. VALUATION OF RESIDENTIAL IMPROVEMENTS, 1980. The rankings are based on 1959 valuations. *See Table 50 in Appendix H for details by subsector.*

assumed that the position of one subsector with respect to another, in terms of the broad valuation groups, will not change.

The pattern of valuation rankings is shown in Figure 44. The outstanding feature of concentric zones increasing in value is clearly incomplete. Low value housing will be concentrated in and adjacent to the south and east-central areas with high value housing beyond on the hill suburbs. Low value housing will occur in the eastern seaside suburban areas while a long and broad tongue of high values will extend from the northwest city margins right in to the boundary of the central city area. If the assumption is correct that the higher value areas will own and use cars more than other areas, it is clear that much of the movement from these subsectors to the city centre will be over relatively long distances. In addition the length and extent of the high value zone in the northwest will result in large traffic movement being channelled into fewer and fewer routes as the centre of the city is approached. For these reasons alone, it is necessary to consider the valuation of improvements in residential property

in forecasting traffic in 1980 since this element acts as one variable in probable traffic origins and destinations from and to residential areas.

EMPLOYMENT

Consideration has so far been given to elements in the city which will be important in projecting the sources of traffic originating and terminating at the residence, and for this purpose population estimates of the surrounding districts in general and of the Internal Area in particular were made for 1980. As the large majority of the population—approaching 350,000 in the Christchurch area—will live within the Internal Area, it was necessary to obtain a measure of their distribution by subsectors and this was done on the basis of allocating the 87,280 households among the living areas of the city. It is now appropriate to consider the places of work and the business and shopping centres because these will be the points of destination for most of the traffic of 1980 which will leave the residential areas.

COMMERCIAL EMPLOYMENT

While the concept of living area involved land used for commercial employment in shops, this land use was considered as only of immediate local significance to each living area. In addition to these local shops, significant commercial centres serve wider areas than that envisaged in this concept. The analysis of the 1959 traffic survey suggested that a subsector with over 40 persons employed in commerce was of more than immediate local significance; in other words, this size of commercial land use has an influence on travel beyond the confines of the subsector in which the shops are located. The survey also showed that, in general, commercial employment in such numbers occurs in single centres rather than in a number of dispersed and small units. In 1959 the population outside the inner area of the city (Sector 0) was contained in approximately 52,000 households and was served by almost 2,500 people employed in suburban shopping centres. In 1980 the number of households to be served outside the inner area is forecast as approximately 84,000 and requiring about 4,600 persons employed in shopping centres. This latter figure, in comparison to that for 1959, makes greater allowance for the use of suburban centres compared with central business areas (in Sector 0) and this is likely to occur because, as the town grows outwards, the central area will become more remote and, relative to population growth, its use will diminish although, of course, there will be an absolute increase in its use over that of 1959. In distributing the suburban increase among commercial activities, major and minor centres were defined; a major commercial centre was defined as having 100 or more persons employed in commerce, and a minor centre as having less than 100 persons but with a minimum of six shops.

Because of their power in attracting traffic over considerable distances the major shopping centres of 1980 require careful consideration with respect to their location by subsectors. It was forecast that by 1980 there would be 14 major commercial centres employing some 2,750 persons. The expected distribution of these centres is shown in Figure 45. All except two of these centres are already well established and are expected to expand to meet the demands of the increased population of their market areas. The two new centres lie in the northwest area into which population is already rapidly spreading and where very significant future increases in residential building will occur as the city grows. The first of these two represents the large centre planned on the south side of Harewood Road (subsector 37). The second represents a new major shopping centre that will be required as population increases towards the urban margins of the northwest area: the exact location is not yet determined but is expected to be somewhere within subsector 25.

The distribution of the major commercial centres calls for further comment in some areas. In the northeast part of the city the residential areas have reasonable access to minor centres and have been provided with rather less in the way of large shopping centres; this is also the case in the southern parts of the city where the population is spread in a broad arc in which it would be difficult to locate a major centre that would have a sufficiently large and conveniently accessible

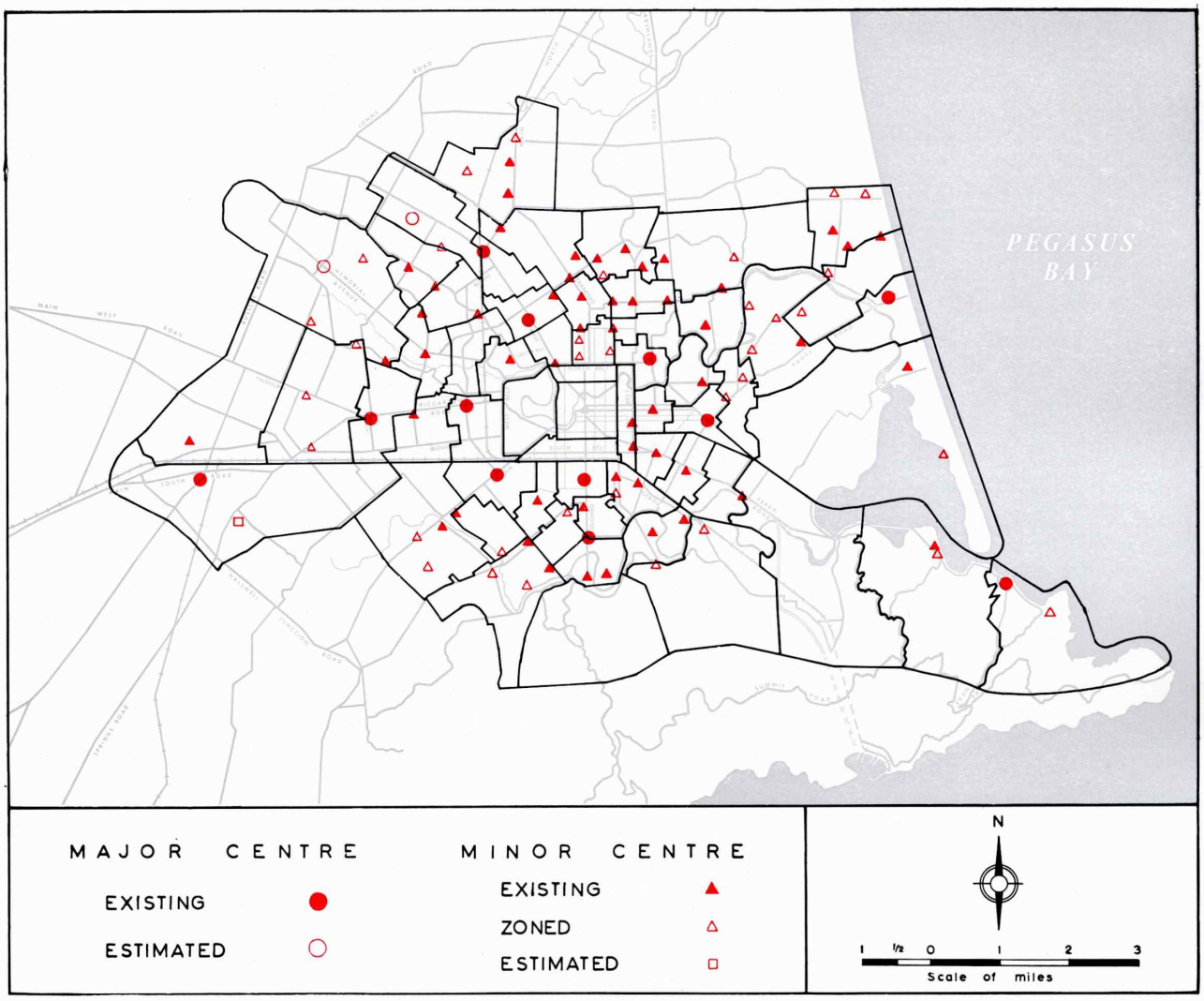


Fig. 45. SUBURBAN SHOPPING CENTRES, 1980. *See Table 48 in Appendix H for details by subsector.*

market area. Although it might appear that both Addington and Sydenham would be expected to grow because of their locations in the path of movement between the south and southwest, and the Central Traffic District, it was considered that their physical nature and the industrial environment will favour the retention of local servicing functions for those working nearby, rather than attract residents from a wide area of the city. To the southeast a major shopping centre is shown at Sumner to serve the more remote suburbs in this part of the urban area. Beyond these considerations no allowance has been made for the development of major shopping centres as it was considered that there would be insufficient residential population in the market areas. Development in the southeast, subsequent to the opening of the tunnel road to Lyttelton, and subsequent to the urban occupation of land towards the estuary, may give rise to a major commercial centre in this area but it cannot be reasonably forecast as yet. The balance of the predicted

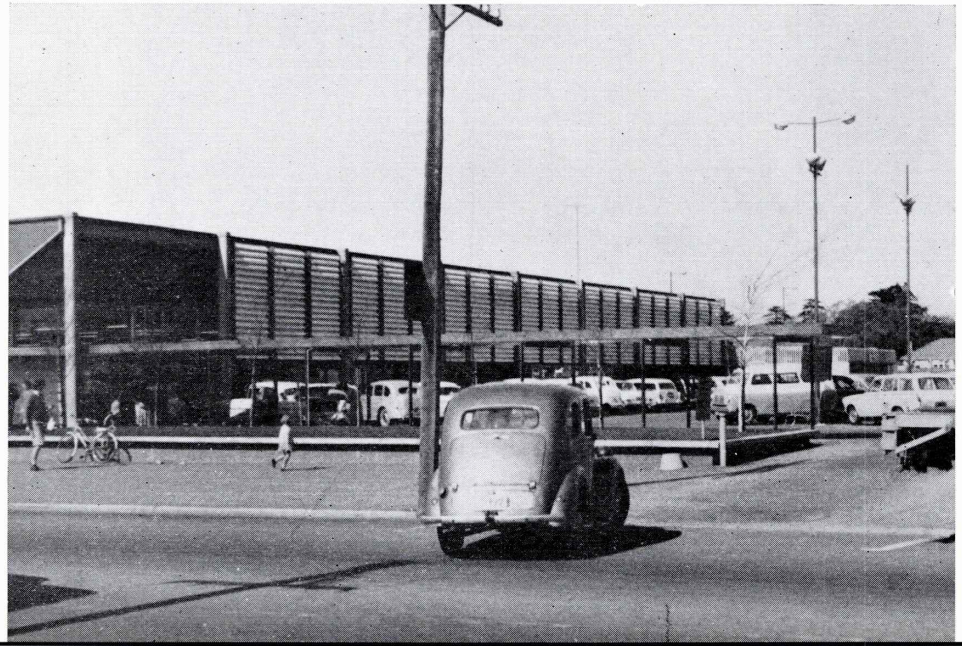
Plate XIX

Growth and Change

More office space in the centre

Courtesy of Housing Division, Ministry of Works

Design for new shopping centre in northwest area (Bishopdale)



Increased suburban shopping

increase in commercial employment in the suburban areas is about 1,900 people but these are expected to be in minor centres widely spread over the suburbs and their attraction for relatively long distance travel is of much less significance.

It has already been suggested that the commercial activities of central business areas (in Sector 0) are likely to decline relative to the total of suburban centres, because of the increasing remoteness of a larger proportion of the population as the city spreads and grows. For this reason suburban centres are estimated to have a higher rate of increase in employment than business areas in Sector 0[2]. Nevertheless the latter will still contain the bulk of those employed in commerce, of the order of 85 per cent of the total for the Christchurch urban area and will continue to exert the greatest single attractive force in terms of travel for commercial purposes.

The distribution of shopping centres in 1980 assumes that present shopping habits will largely continue. There is, of course, the possibility that supermarkets, modified from overseas types to suit local conditions and city size, will develop, in which case the 1980 pattern described above might be changed in some respects. However, allowance has in part been made for this by assuming a greater increase in employment in suburban commercial centres relative to central business areas. It is also pertinent to recall that the lack of physical determinants of site on growth permits the planning of facilities for the 1980 population and the adjustment of traffic routes to their respective catchment areas. For these reasons, it is reasonable to assume that the distribution and size of major shopping centres in 1980 will follow the general pattern as estimated. In 1959 there was very little evidence to suggest how the supermarket type of shopping centre would develop in Christchurch or how the shopping habits might be affected; hence there is something of an unknown element but that is always true of any forecast which must be adjusted in the course of time to meet changing circumstances and habits.

[2] The Central Traffic District, which includes a large part of the central business district, is expected to have a relative increase in commercial employment (from 77% in 1959 to 80% in 1980 of total commercial employment) but adjacent subsectors of Sector 0 are expected to decrease, giving an overall decrease for Sector 0. See Table 48 in Appendix H for details by subsector.

INDUSTRIAL EMPLOYMENT

In considering the use of land for manufacturing, the areas already zoned for industry were considered as being fully occupied by industrial plants (Fig. 46). Employment was estimated on the basis of the pattern of existing densities except where some modification might be expected because of present trends in the layout and design of factories and where it was not expected that all the zoned land will be fully occupied for manufacturing by 1980. The latter was particularly the case with the zone overlapping the northwest margin of the urban fence where it was assumed that by 1980 this major zone will be only half developed in terms of numbers employed.

From studies of existing local industries and the standards adopted in some instances overseas, it appears that the future density standards appropriate for Christchurch will be of three kinds. The intensive zones in the city centre will have 50 workers per acre, the extensive zones in outlying areas 8 workers per acre, and the intermediate zones about 18 workers per acre (Fig. 47). In addition to the major zones are establishments which will be either non-conforming or subject to spot-zoning.

Working along these lines, the total employment in industry in 1980 will be 48,000 in comparison with 28,880 in 1959. This represents a slightly higher proportion of the total employed workers of 1980 than in 1959 but from a study of other major urban centres in New Zealand it was seen that the larger centres employed slightly more of their total population and that a higher proportion of those employed are in manufacturing. It appears, therefore, that there is sufficient space for industrial firms to employ 19,000 more workers forecast for 1980 or an increase of 66 per cent over 1959.

TOTAL EMPLOYMENT

The city is dynamic and changes occur in land use in response to the growth of population, the

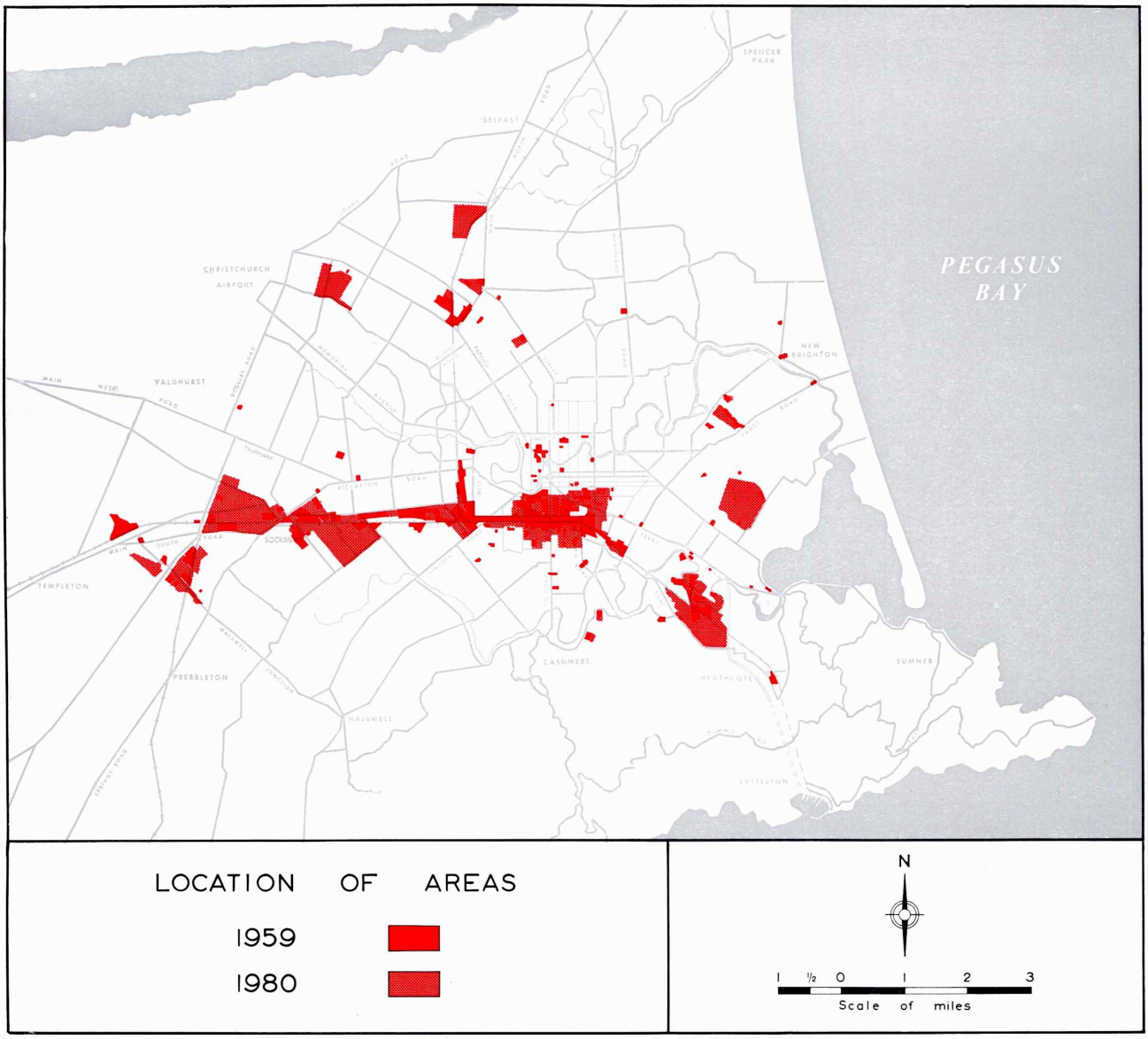


Fig. 46. Industrial land, 1959 and 1980.

habits and desires of the people, and the prevailing economic and social opportunities. Its population size, for example, varies through time in response to numerous economic and demographic factors. Or again, the relative position of the basic functions, one with the other, may alter as new economic activities appear and older ones decline. Within the city, too, there may occur marked changes in the distribution patterns of land use functions, population and economic opportunity, producing not only a greater volume of traffic and movement of people but also result-

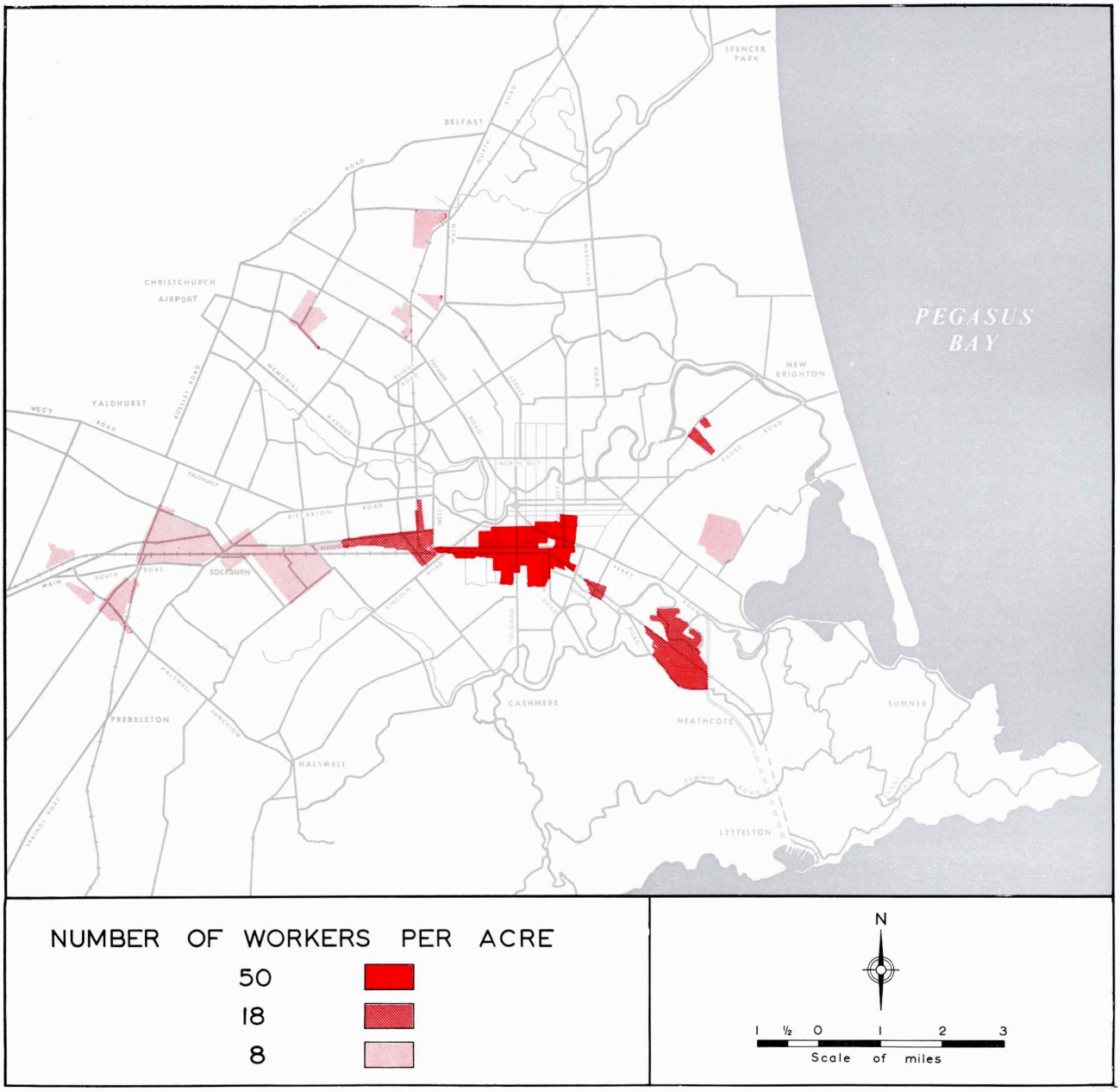


Fig. 47. Industrial density, 1980: workers per acre.

ing in changing patterns of movement. It is necessary, therefore, to attempt to predict the major of these changes in order to facilitate the prediction of the increase in volume of and changes in pattern of traffic movement. Particular attention has been given to the growth in population of the Internal Area and of the surrounding areas, to the places where this increased population will live and to the land use functions associated with commercial and industrial em-

TABLE 16

HOUSEHOLDS AND EMPLOYMENT IN THE INTERNAL AREA: 1959 AND 1980

YEAR	NUMBER OF HOUSEHOLDS	EMPLOYMENT		
		Total	*Industrial*	*Other*
1959	54,912	69,565	28,880	40,685
1980	87,280	114,000	48,000	66,000

See Tables 47 and 48 in Appendix H for further details.

ployment. These changes have been predicted for 1980 primarily in relation to the land inside the urban fence and it is assumed that all this area will be fully occupied by urban activities by 1980.

Within the Internal Area, Christchurch is expected to contain 310,000 people in 1980, an increase of 59 per cent over the 1959 population of 196,000. Table 16 sets out the comparison between 1959 and 1980 for population in terms of households and employment.

Total employment is estimated on the basis of a slightly larger proportion of the total population being employed in 1980 compared to 1959, on the assumption that the larger city will follow the general trend of other centres in employing relatively more of its population. Following a similar general principle, industry is estimated to employ relatively more people in 1980 than in 1959. The other avenues for employment—in commerce, education, public services in particular—are expected to be more directly in proportion to the number of households and in a similar way the forecast for 1980 by subsectors was made.

AREAS OF CHANGE

In summary, Table 17 and Figure 48 show the way in which the employment and hence the land use functions are expected to change from 1959 to 1980 in the major parts of the Internal Area. Within the Belt Cordon Line (Sector 0) the non-industrial activities will increase five times more rapidly than industry as the central area of the city expands its functions as a central business district. Within the heart of this area—the Central Traffic District (subsector 01)—industry will show an absolute decrease. Other functions will expand and, being able and willing

TABLE 17

AREAL CHANGES OF EMPLOYMENT IN THE INTERNAL AREA: 1959-1980

AREA	INDUSTRY			OTHER			TOTAL		
	1959	*1980*	% *Inc.*	*1959*	*1980*	% *Inc.*	*1959*	*1980*	% *Inc.*
Within Belt Cordon Line* ..	13,511	15,000	11	28,272	43,611	54	41,783	58,611	40
Fringe of Belt Cordon Line† ..	6,437	11,838	84	3,598	5,231	45	10,035	17,069	70
Remainder of Internal Area ..	8,932	21,162	137	8,815	17,158	95	17,747	38,320	116
TOTAL INTERNAL AREA ..	28,880	48,000	66	40,685	66,000	62	69,565	114,000	64

* Sector 0.
† Subsectors 11, 51, 61, 71, 81, 82, 91.
See Table 48 in Appendix H for further details.

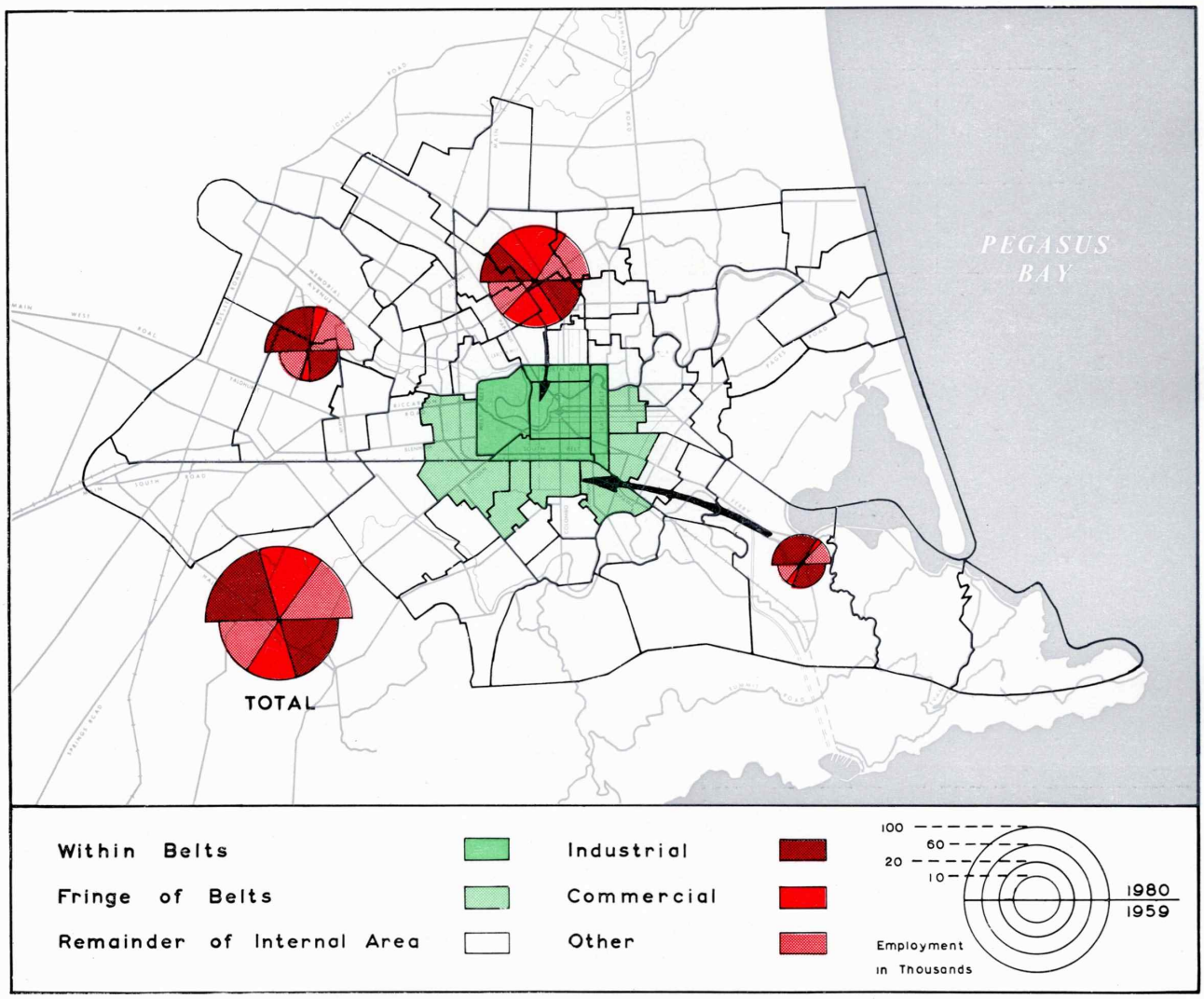


Fig. 48. CHANGES OF EMPLOYMENT WITHIN THE INTERNAL AREA, 1959-1980. *See Table 17.*

to pay the high rental value of the city core, they will price manufacturing out of this very competitive area. Within the remainder of the area inside the Belt Cordon Line the same principle will operate but to a lesser extent, and while industry increases, non-industrial employment will increase at a faster rate.

Further out, beyond the Belt Cordon Line but immediately adjacent to it in the east, south and west, the principle will be reversed and manufacturing industry will increase more rapidly than the combination of other types of employment. In the remainder of the city, industry will continue to show the predominant increases but not so significantly in comparison to other employment and this will be a result of the expansion of commerce, education and similar employment to serve the new and rapidly expanding outer suburban areas.

This is the broad pattern of change that will occur between 1959 and 1980 and indicates the dynamic character of a growing city and the

Plate XX. CENTRAL INDUSTRIAL DISTRICT OF CHRISTCHURCH. Industry dominates the southern part of the central business district (left of railway) and will continue to expand south of the railway (right).

Plate XXI. SOUTHWEST CHRISTCHURCH. From the stockyards and railway workshops (in foreground) industry is spreading west and southwest and will continue to expand along major transport routes. Riccarton Borough is on right, Sockburn, Hornby and Islington in distance.

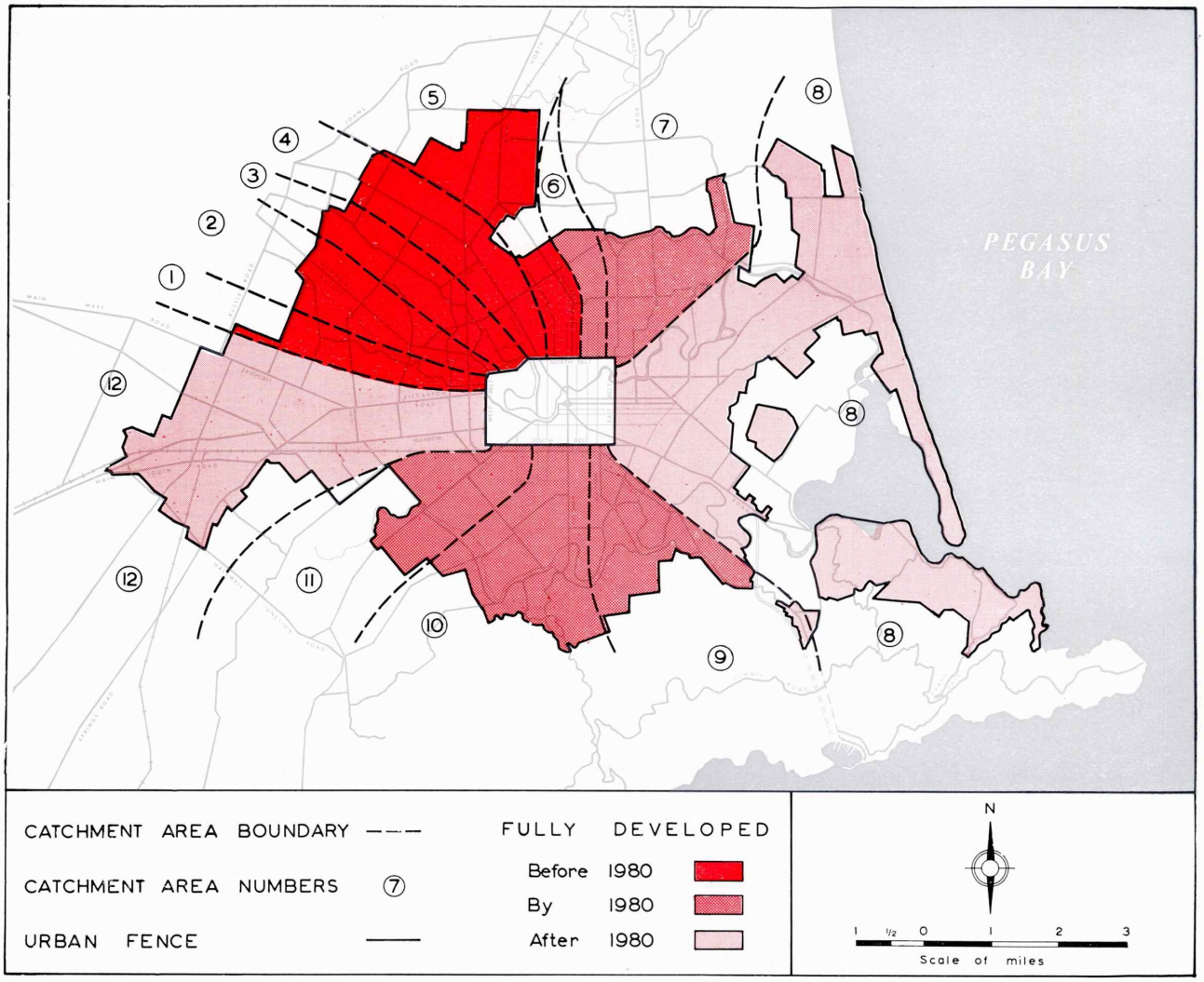


Fig. 49. URBAN GROWTH RELATIVE TO THE URBAN FENCE, AS AT 1980. *See Table 56 in Appendix H for further details.*

changing land use functions which must be considered in attempting to forecast future travel in 1980. To make a reasonably reliable prediction of land use functions, it is necessary to realise that because urban land is scarce and valuable, the activities of urban areas tend towards a rational arrangement because of the changes in land values as one moves from the high value central area, which commands the greatest accessibility to the city population, towards the lower value and less accessible suburban areas in the outlying margins. In response to the changing values of land, the uses of the land for urban activities are economically determined; those activities which can afford to pay higher rents force out of the most valuable central areas those functions that are unable to meet the increased charges. In this way the process affects the arrangement of activities and permits a reasonable prediction of the future character of the city.

It is not to be expected that the city will develop in every respect along the lines forecast and in fact it is impossible to predict accurately in any detail as long as a large element of private

enterprise and individual choice is allowed to operate. In considering the growth of commercial centres the difficulties of prediction were shown by the unknown role of the supermarket. The city will not grow in all directions at an even or regular rate although for the purposes of forecasting traffic it was assumed that the 1980 population will be largely contained within the Internal Area and that all the area therein will be fully developed for urban purposes by 1980. The growth of some sectors of the city will result in them reaching the urban fence before 1980, others by 1980, and the remainder after 1980. The distribution of these varied rates of growth relative to available land within the urban fence will in part be determined by the programme of major roadway construction and this is as yet unknown. However, in considering present trends in relation to land use forecasts, an estimate for the various parts of the city has been made with reference to the major traffic radials and their respective catchment areas (Fig. 49).

The northwestern area is shown as the earliest to be fully occupied, and before 1980, while the eastern and western traffic catchments are shown not to be fully occupied for urban purposes until after 1980; the balance of the city is shown to be more in sympathy with the general assumption. While, for the purposes of forecasting traffic, the Internal Area was generally assumed to contain the 1980 population, the relative rates of growth from one urban sector to another will have filled in some of the available areas within the urban fence at different times from that of the design year.

VEHICLE OWNERSHIP

The account so far has shown how the estimation of future traffic must make allowance for the changes of land use, population and economic growth. Coinciding with these changes in the pattern of living will be changes in the number of vehicles and perhaps of personal habit as to vehicle use.

It is obviously important that any estimate of the increase in the number of motor vehicles be as realistic as possible. It is also important to determine how it should be applied. The owners of motor vehicles will almost certainly make some journeys that they would not consider if forced to rely upon other modes of transport; to that extent, the ownership of vehicles is itself a source of increased travel and the number of journeys must be expected to rise as the vehicle ownership index rises. In addition the growth of the city and the spread of homes and places of employment will increase the amount of travel and make car ownership a more attractive proposition. In this study growth factors are calculated for urban developments which will affect travel in the region. These already reflect, to some extent, the concurrent increase in car ownership which enables the urban area to spread without loss of convenience.

REGISTERED VEHICLES

The relationship of vehicle ownership and population assumes that, as the proportion of vehicles to population increases, there will be a slowing down in the rate of increase. Since the United States of America already has a higher rate of motor vehicle ownership than New Zealand it was believed that past trends in the United States might give an indication of what could be expected in the future trends for New Zealand.

Figure 50 shows that past trends of motor vehicle ownership in New Zealand were very similar to earlier trends of vehicle ownership in the United States. For want of better information, the rate of growth of vehicle ownership in the United States was accepted as applicable to New Zealand generally and to Christchurch in particular.[3] This was the basis of predictions first made in 1957 and subsequently adjusted in 1961. Figure 51 shows on a logarithmic vertical scale the increases of population, of total vehicles, and of cars and trade vehicles which have occurred since 1936 and the forecasts to 1980. Tables 18, 19 and 20 give numerical information derived from this graph.

The 'natural law of growth' is one of an ever

[3] In Great Britain, the average annual rate of increase (on a compound basis) for all motor vehicles was eight per cent from 1955 to 1960; it was 12 per cent from 1958 to 1959 and seven per cent from 1959 to 1960. See Department of Scientific and Industrial Research: *Road Research 1960*, London, 1961, p. 10.

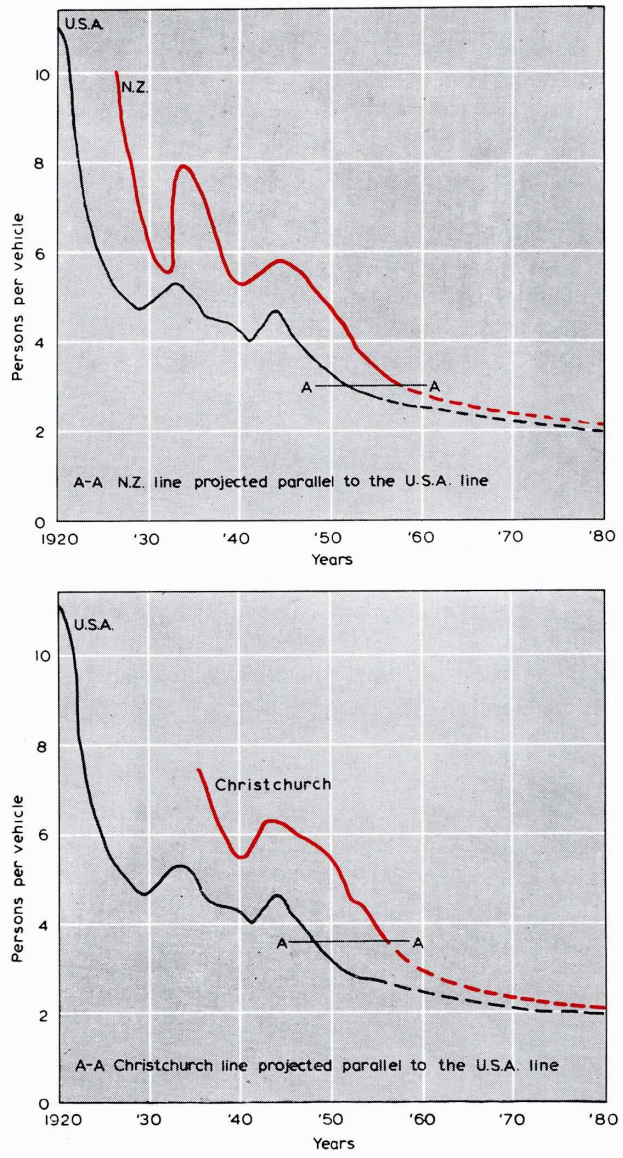


Fig. 50. VEHICLE OWNERSHIP, 1920-1980: NEW ZEALAND AND CHRISTCHURCH COMPARED TO U.S.A. Source: For U.S.A., from U.S. Bureau of Public Roads; for New Zealand, from *New Zealand Official Yearbook* (annual) and Office of Registrar of Motor Vehicles; for Christchurch, see Table 49 in Appendix H.

declining rate of growth as the maximum size is approached. This is universally true and all that has been drawn from American experience of vehicle ownership, is the rate at which growth is

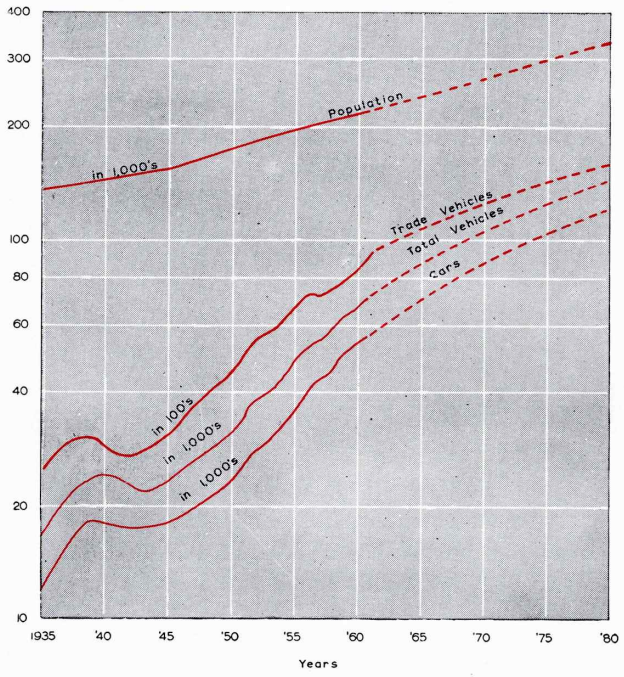


Fig. 51. POPULATION AND VEHICLES, 1935-1980. See Table 49 in Appendix H for further details.

assumed to slow down. If the assumed rate proves to be greater or smaller than what actually occurs, it means that traffic very much like that now forecast for 1980, will occur a year or two before, or a year or two after, that date.

In further justification it may be said that a study has been made of the period from 1925 to 1959, a period which contains the depression of the 1930's, the years of World War II, and some post-war periods of import restrictions. In all cases, after a period when motor vehicle registrations have decreased, the leeway has been made good and, over periods of about 10 years, the intermittent incidence of low vehicle registration has had little effect.

VEHICLE UTILISATION

Before leaving the matter of private car ownership it is necessary to consider the other modes of travel which are in competition with private cars. These are likely to be used, more or less, according to the changes in car ownership and utilisation. Particular attention must be paid to public bus transport and cycle transport.

TABLE 18

POPULATION AND VEHICLES FOR CHRISTCHURCH*: 1949, 1959 AND 1980

YEAR	*Population*	*Total Vehicles*	*Persons per Vehicle*	*Cars*	*Persons Per Car*	*Trade Vehicles*	*Persons Per Trade Vehicle*
1949	172,000	30,907	5.57	22,732	7.57	4,284	40.2
1959	217,330	66,723	3.26	53,117	4.07	7,969	27.1
1980	330,800	152,500	2.17	125,620	2.63	16,150	20.5

* Defined as Christchurch City; Riccarton and Lyttelton Boroughs; Halswell, Heathcote, Paparua, and Waimairi Counties. See Table 49 in Appendix H for further details.

TABLE 19

PROPORTIONATE INCREASES OF POPULATION, AND VEHICLE OWNERSHIP FOR CHRISTCHURCH:* 1949-1959 AND 1959-1980

YEARS	*Population Proportionate Increase*	*'Total' Vehicle Proportionate Increase Per Head of Population*	*Car Proportionate Increase Per Head of Population*	*Trade Vehicle Proportionate Increase Per Head of Population*
1949-1959	1.26	1.71	1.86	1.48
1959-1980	1.52	1.50	1.55	1.33

* Defined as Christchurch City; Riccarton and Lyttelton Boroughs; Halswell, Heathcote, Paparua, and Waimairi Counties. See Table 49 in Appendix H for further details.

TABLE 20

GROWTH OF POPULATION AND VEHICLES FOR CHRISTCHURCH:* APPROXIMATE AVERAGE PERCENTAGE INCREASE PER ANNUM, 1949-1959 AND 1959-1980

YEARS	*Population*	*Total Vehicles*	*Cars*	*Trade Vehicles*
1949-1959	$2\frac{3}{8}\%$	8%	$8\frac{3}{4}\%$	$6\frac{1}{2}\%$
1959-1980	2%	4%	$4\frac{1}{4}\%$	$3\frac{1}{2}\%$

* Defined as Christchurch City; Riccarton and Lyttelton Boroughs; Halswell, Heathcote, Paparua, and Waimairi Counties. See Table 49 in Appendix H for further details.

The general pattern that emerges in many countries is of a rapidly increasing use of private cars and of a negligible growth, and sometimes a decline, in the use of mass transportation by bus or train. Moreover, the relative decline in the use of public transportation may frequently be found in towns which are expanding in area, and where the milage to be run per passenger trip tends to increase. Off-peak traffic by mass transportation usually tends to decrease while peak hour traffic increases slowly or remains about the same. These changes lead to uneconomic demands for extra equipment to handle the peak loads and to increases in the nonproductive milage; the result is an increase in the cost of public transport services.

The inherent advantages that may be attributed to the private car owner are those of saving time and the convenience of being able to make his journey when he chooses and without being dependent upon a timetable. He may in addition more readily make multipurpose journeys. The

costs of owning and running private vehicles are generally greater than that of bus fares (Appendix G). The cost lies largely in the ownership of a wasting asset whose depreciation varies with time as well as with milage. The owner of such an asset can be expected to make the maximum possible use of his vehicle so as to exploit fully the advantages of convenience and savings in time which it offers and thereby, to get the greatest possible return on his investment.

Private cars require a large area for parking and studies indicate the need by 1980 for about 20,000 parking spaces (each being of about 300 sq. ft.) in the Central Traffic District. Yet accessibility to the city centre is its life blood and without ease of access the central business area is likely to decline in importance, with economic and social consequences to the whole community. Consideration of this problem is resumed in Chapter Six.

For the purpose of forecasting it is assumed that there will be no frustration of traffic by inadequacies of roads or shortage of parking accommodation, and that all who have the need to travel and own a car will be able to use it.

In Christchurch many car owners possess cycles which they sometimes use for a variety of reasons. With the extension of car ownership, many persons who now own and use cycles only, may in future become motorists. The problem is to predict whether such persons will retain the use of their cycles as an alternative means of transport to such an extent as would reduce the average annual utilisation of their cars.

It is, of course, very difficult to give an objective answer to such questions but some relevant statements can be made with confidence; namely that nearly all present motorists have been cyclists at some time in the past, and that the cost of cycles is trifling compared with that of cars, so that car owners could also own cycles if they so wished. The number of cycles appears to be static and with the increasing child population it is reasonable to assume that the number of cycles owned by adults is decreasing. From these statements it seems reasonable to argue that the speed, comfort and convenience of motoring deters present motorists from using cycles to any great extent. To pass from owning a cycle to owning both a car and a cycle, is an increment to one's standard of living. There seems no good reason to expect the future group, on gaining this increment, to behave differently from other groups in the past.

Plate XXII. '. . . . convenience outweighs costs . . . .'

The formulae which have been derived to 'explain' travel have all linked cycle travel inversely with distance. Christchurch of the future will impose greater distances on those travelling for work, business, or pleasure to the Central Traffic District and this fact clearly indicates that the use of cycles is more likely to be reduced than to be increased.

Other things being equal it appears that other modes of transport will decline in importance with greater use of private cars. The increased vehicle ownership index will certainly result, in part, from some families having more than one car. 'Second' cars may conceivably make fewer trips than 'first' cars but this is not certain and it must be remembered that a 'second' car also acts as a reserve for the 'first' and is available if that should break down. 'Second' cars can increase the use of 'first' cars by releasing them from the garage if, for example, the wife requires a car. In these cases the 'second' car does as much as the 'first' used to do. Overseas experience suggests that the annual milage per vehicle changes very little.

SUMMARY

This chapter has examined the probable lines of economic expansion in the Christchurch area during the next two decades. Although in 1980 it may not still contain its present share of New Zealand's population, Christchurch is likely to increase faster than the South Island as a whole; in other words a greater proportion of the population of the South Island in 1980 would be in the Christchurch area.

The population should reach a total approaching 350,000 by 1980, an increase of about 60 per cent over 1959. The enlarged population is expected to have higher material standards of living and, following estimated trends, will have higher average car ownership. Fewer families will be without cars and more will own more than one car. It is anticipated that the number of cars will more than double in the two decades. The sum total of these numbers is a very great demand for highway travel.

CHAPTER FIVE

Estimating Future Travel

THE SURVEYS of 1959 were analysed to show the patterns of movement of people and vehicles at that time and these were related to the nature and extent of the various functions of the different parts of the city. During the next two decades, the extension of the urban area, increasing developments in urban activities and growing numbers of people will together lead to a great demand for travel in the Christchurch area.

This chapter is concerned with the procedures by which the data, already presented, was used to forecast 1980 travel and hence traffic. Stated briefly, the method was to derive formulae or other relationships which related 1959 trip generation to 1959 land use, employment, and other selected variables. Using projected or estimated future values of these variables the same formulae or graphs were used to make the forecast. The methods used were somewhat complex: they are therefore dealt with generally in this section and more complex matters are treated in Appendices.

THE TRAFFIC AREAS

The Central Traffic District is an area in which rebuilding is occurring and older houses are giving way to large commercial buildings, car parks, institutional buildings and similar forms. It is a powerful collective generator of trips, or focal point to which traffic flows, and is the original or terminal point for very many journeys. Its land is already fully developed but it contains many inefficient, old buildings which are ripe for redevelopment. Redevelopment costs are generally higher than the costs of building elsewhere and this favours redevelopment of the land for commercial or other intensive uses which are willing and able to meet the high costs associated with maximum accessibility.

Changes in trip patterns will occur as the Central Traffic District redevelops but these will more probably be in magnitude than in kind and will be related to the increasing opportunities provided for employment, business, and social and recreational pursuits. The Central Traffic District is likely to remain the major, single, collective generator of traffic and the principal terminus. Future travel and traffic will be greater than at present but the modes, purposes, and timing of traffic will be similar to that existing today.

The remainder of the Internal Area (the suburban subsectors) has a mixed nature; it contains many industrial and commercial premises but is extensively occupied by those serving local residential needs and by residential buildings. Traffic is heavy in total but widely dispersed. All points will be termini for some journeys and a number of sites within the area will be terminal points for many journeys but such sites are more widely dispersed than in the case of the Central Traffic District. Of the vehicles on a given street at any time, probably only a minority are about to terminate their journeys.

Within some of the suburban subsectors land is still available for development. The existing residential properties have usually sufficient residual life to make their early demolition and replacement uneconomic and there is thus less financial incentive to replace residential by other land uses. The patterns of future trips generated by suburban subsectors are likely to resemble those now existing; however to predict the number for each of the various types of trips, more factors will have to be used than are needed for the estimation of movements to and from the Central Traffic District.

The localities of the External Area adjacent to Christchurch are largely undeveloped for urban purposes, the traffic is light and it is here that the

greatest relative changes may occur in land use and in trip generation. The existing patterns of travel and traffic may therefore provide a very inadequate basis upon which to forecast the future.

DEVELOPING FORMULAE

The complex way in which utilisation of different modes of travel varies from one area to another has been the subject of much of the earlier part of this study. Because of the varied characteristics of the Central Traffic District, the remainder of the Internal Area, and the External Area, it has been necessary to use different methods, from one area to another, to estimate future movements. For similar reasons a limited number of formulae would not serve to fit the 1959 data closely for all areas, modes of travel, and trip purposes,and it was necessary to develop formulae to cover many of the possible combinations of these conditions.

FORMULAE REQUIRED

The analysis of 1959 data suggests that separate formulae or other relationships are likely to be required for three area movements: namely, travel to the Central Traffic District, trip generation of subsectors within the Internal Area, and trip generation of localities in the External Area. Formulae are also required to deal separately with trips by purpose and by mode of travel. Thus many hundreds of formulae would be required to cover all possible combinations of area, purpose, and mode but in fact most of these combinations were not used. The elimination of most combinations from consideration became possible for two reasons. Firstly, many area–purpose–mode of travel combinations involved too small a number of trips either to be worthy of separate study or to yield formulae which could be considered reliable. Secondly, the trips generated by certain purposes were not capable of being related to the variables that explained the greater part of the trip generation.

As has already been shown at some length, the variables which may be expected to account for travel for any particular subsector–purpose–mode combination include the valuation of residential property, total employment, and commercial employment. These may be regarded as measures of the traffic generating capacity of, respectively, residential areas, work places, and of shops and the like. Journey distance has also been seen as a variable in any formulae which may be derived to represent movement and there is of course a hidden characteristic, number of households, because the unit area in analysis, the subsector, was defined in terms of approximately 1,000 households[1] (Table 50 in Appendix H). The derived formulae do not always include all of these variables, one or more of which was sometimes found to be insignificant in the explanation of trips generated by a particular subsector–purpose–mode combination.

DATA PREDICTED

The forecasting of future travel can be of two forms (Fig. 52). There is firstly, the calculation of the total number of trips generated by subsectors in terms of mode and purpose. This provides no direct information as to travel between specific subsectors; that is, it is not known which subsectors are at the other ends of these trips. The second type is the direct forecasting of travel between specific subsectors having been given the land use characteristics of each; that is, all the estimated journeys will be between particular pairs of subsectors.

The former method is easier to use but has the disadvantage that further assumptions and calculations are then required in order to assess travel between pairs of subsectors. Because of the difficulty of establishing general relationships for intersubsector travel, this method has been used for most of the subsectors in the present study. The allocation of future trips between all possible pairs of subsectors was carried out by the method developed by Fratar (Appendix E).

The second method reduces forecasting to a single step, instead of two, but so far is a proved and accepted method for certain special studies only. The special studies for which it is suited are those where a dominant generator can be identified whose traffic is likely to grow in volume but

[1] A household unit is defined in terms of a group of rooms or a single room, occupied or intended for occupancy as separate living quarters, by a family or other group of persons living together or by a person living alone.

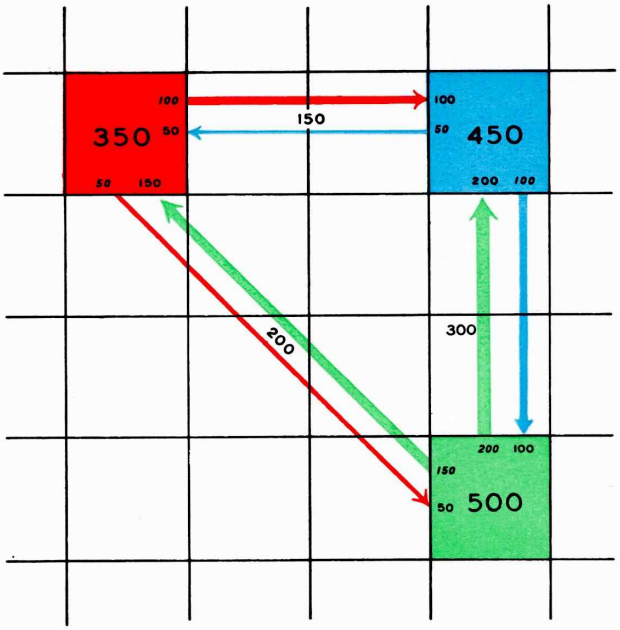


Fig. 52. TRIP GENERATION AND TRAVEL: A DIAGRAMMATIC REPRESENTATION. In this illustration it is apparent that the total trip generation of the subsectors (1,300) is twice that of total travel between subsectors (650).

to arrive for purposes, by routes and at times similar to those of present traffic. The central business district of a city is, in general, an example of a dominant generator to which this more positive method is suited. By contrast, other subsectors will vary greatly in the proportions by which they develop for residential, commercial, industrial or other uses, and in the nature of the resulting increases of traffic. A particular subsector may exhibit an overall growth of trip generation but the interplay of its traffic with other subsectors may vary so greatly as to defy any direct attempts to forecast its increased travel: that is the second method is unsuitable for subsectors and localities other than the Central Traffic District. With the Central Traffic District of Christchurch being the origin and destination of 40 per cent of all internal trips, the second method overcomes some of the objections to the less certain first method and, at the same time, makes the use of the first method more acceptable for the remaining intersubsector travel.

GENERAL METHOD

In the Christchurch study the first classification of total travel for purposes of analysis was threefold: into either travel between subsectors, that is within the Internal Area, or travel between a locality and a subsector, that is between the External and Internal Areas, or travel between localities, that is through traffic not stopping in the Internal Area. Separate sets of tables were prepared for each mode of travel, the total number of persons travelling, and the total number of motor vehicles involved (Table 53 in Appendix H).

The travel represented by these tables was examined in three ways; firstly, as travel to the Central Traffic District, that is trips to the Central Traffic District from subsectors and localities; secondly, as subsector trip generation in terms of outward movements from subsectors to other subsectors and localities; and thirdly, as trip generation of external localities in terms of outward movements from localities which terminate in or pass through the Internal Area. The manner in which this examination was carried out is described in succeeding sections of this chapter where it is explained how relationships, which permitted 1980 forecasts in the same terms, were established.

It will be apparent that the total travel occurring within the Internal Area consists of the following parts:

(A) travel between subsectors and the Central Traffic District
plus (B) travel between suburban subsectors (subsectors excluding the Central Traffic District)
plus (C) travel between subsectors and localities
plus (D) travel between localities and passing through the Internal Area.

In the Christchurch study, as will be seen later in this chapter, the analysis and forecast of Part (A) was made directly from the available data. From a study of subsector trip generation the forecast of Part (B) was deduced. This was done by subtracting the amount of travel to the Central Traffic District (A) and travel between subsectors and localities (C) from the total trip generation of each subsector, and distributing

the remainder among the suburban subsectors by an acknowledged method, the Fratar method. The relatively minor Parts (C) and (D) were dealt with in a manner that combined both these approaches.

TRAVEL TO CENTRE

The Central Traffic District's function and character are quite different from those of any other portion of the city and the formulae and relationships derived to simulate its 1959 traffic (and to predict its 1980 traffic) have been determined separately from those used for the remainder of the Internal Area. One other subsector (05), that containing Hagley Park, the Public Hospital and other institutions, has for the same reason been the subject of a separate study.

All journeys are between two points and the travel considered here is that between the Central Traffic District on one hand and the remaining subsectors on the other. Each of the latter subsectors contains approximately 1,000 households and the formulae developed therefore predict the number of trips, per 1,000 households, to the Central Traffic District, according to the characteristics of the respective subsectors.

THE FORMULAE

The analysis of 1959 trip generation in Chapter Three led to a final assessment of variables for use in developing formulae for the estimation of future traffic. These were four in number:

Average valuation of residential improvements	V
Total employment	E
Commercial employment in defined shopping centres	S
Distance of assumed traffic centroid from centre of city (Cathedral Square)	D

The analysis of 1959 trip purposes showed the following to be of significance:

To work in Central Traffic District—first trip	T_{tw}
Return to work in Central Traffic District after lunch	T_{twl}
To school in Central Traffic District	T_{sch}
Business trips to Central Traffic District	T_b
To shop in Central Traffic District	T_s
Social or recreational trips to Central Traffic District	T_r
To home in Central Traffic District	T_h
Trade vehicle trips to Central Traffic District	T_{tv}

The Internal Area contains 57 subsectors,[2] three within the Belt Cordon Line and 54 between the Belt Cordon Line and the External Cordon Line. To increase the reliability of formulae as a means of forecasting traffic, five adjacent localities of the External Area were included in the calculations, giving a total of 62 originating traffic areas.

For each purpose and mode, it was assumed that trips generated can be expressed by the equation:

$$\text{Trips} = a.\ V^m.\ E^n.\ S^p.\ D^q.$$

where a, m, n, p, q are unknown constants to be determined to give the best fit for the 62 simultaneous equations. These were evaluated by multiple regression on logarithms.

The formulae obtained for travel to the Central Traffic District are given in Table 21.

LIMITATIONS OF THE FORMULAE

The use of the formulae must be considered in relation to the limitations occasioned by the assumptions and data on which they are based. The formulae are derived by regression from the *collective* data of 62 subsectors (including the five localities). Only by chance will the formulae reproduce the correct 1959 travel volume for any *particular* subsector. They are of course equally liable to error as means of predicting 1980 travel for individual subsectors but they may be expected to increase in accuracy when many subsectors are considered together. Strictly speaking the formulae are applicable only within the ranges of the variables from which they were produced; that is extrapolation involves some inaccuracy. Furthermore they cannot be better than the data from which they were derived; the latter was a sample only and subject to the limitations of accuracy to which all samples are prone. Part of the data was obtained by questions which may not always

[2] This total of subsectors in the Internal Area excludes 01 (the Central Traffic District) and 05.

TABLE 21

TRAVEL TO THE CENTRAL TRAFFIC DISTRICT (12 HOURS) 1959: TRIP FORMULAE BY PURPOSE AND MODE

TRIP PURPOSE AND MODE	TRIP FORMULA PER 1,000 HOUSEHOLDS	PERSON TRIPS (INCLUDING FIVE EXTERNAL LOCALITIES)		PERCENTAGE OF VARIATION EXPLAINED	REMARKS
		Number	*Percentage*		
To Work					
Total ..	$T_{tw} = \frac{6.25\ V^{0.40}}{D^{0.44} E^{0.14}}$	24,806	100	51	
By Car ..	$t = \frac{0.0002\ V^{1.99}}{D^{0.45} E^{0.27}}$	7,005	28.2	44	
By Cycle ..	$t = \frac{0.93\ V^{0.75}}{D^{1.06}}$	8,283	33.4	55	
Bus and Train	$t = 106$	6,543	26.4		Subsector average is best estimate.
Other ..	$\frac{362.9}{D^{0.47} E^{0.29}}$	2,975	12.0	16	Poor correlation due to mixture of travel modes.
Business					
Total ..	$T_b = \frac{59.9\ E^{0.28}}{D^{0.38}}$	15,645	100	38	
By Car ..	$t = \frac{46.2\ E^{0.20}}{D^{0.35}}$	7,468	47.7	15	Distance is a strong influence in the case of cyclists but otherwise the formulae have explained only a small part of the variance.
By Cycle ..	$t = \frac{15.0\ E^{0.23}}{D^{0.85}}$	2,244	14.3	47	
Bus and Train	$t = \frac{72.1}{D^{0.45}}$	3,175	20.3	11	
Other ..	$t = 4.88\ E^{0.36}$	2,760	17.7	14	
Shopping					
Total ..	$T_s = \frac{227.9}{D^{0.25}}$	11,533	100	7	Very small part of the variance explained. Although D appears to influence the total, this is only through discouragement of 'Cycle' and 'Other' travel.
By Car ..	$t = 0.13\ V^{0.76}$	2,503	21.7	6	
By Cycle ..	$t = \frac{16.2\ (S+1)^{0.11}}{D^{0.48}}$	1,027	8.9	30	
Bus and Train	$t = 89$	5,529	47.9		Subsector average is best estimate.
Other ..	$t = \frac{31.8\ (S+1)^{0.14}}{D^{0.29}}$	2,474	21.5	14	
Trade Vehicles	$T_{tv} = \frac{10.35\ E^{0.44}}{D^{0.64}}$	6,767*	100	48	

* Vehicle trips only.

TABLE 22

TRAVEL TO THE CENTRAL TRAFFIC DISTRICT (12 HOURS) 1959, BY PURPOSE: OBSERVED AND COMPUTED VOLUMES FOR TWO GROUPS OF SUBSECTORS

PURPOSE	NUMBER OF PERSON TRIPS					
	*Group A**		*Group B***		*Total*	
	Observed	*Computed*	*Observed*	*Computed*	*Observed*	*Computed*
Work	2,716	2,300	3,419	3,365	6,135	5,665
Shopping	1,078	1,129	1,380	1,431	2,458	2,560
Business	1,373	1,461	1,742	1,618	3,115	3,079
		By Graph		*By Graph*		*By Graph*
Lunch	147	315	571	640	718	955
Social-Recreational	216	350	435	640	651	990
		Estimate		*Estimate*		*Estimate*
School†	227	227	43	43	270	270
Home†	105	105	220	220	325	325
TOTAL	5,862	5,887	7,810	7,957	13,672	13,844
TRADE VEHICLES††	458	498	591	540	1,049	1,038

* Group A: Subsectors 14, 15, 16, 25, 26, 37, 38.
** Group B: Subsectors 13, 23, 24, 36, 45, 46, 85, 93.
† No formulae or graphical relationships were established for these purposes. Observed values are included here for completeness.
†† Vehicle trips only.

have been completely or correctly answered. In addition a limited number of variables were used, specifically those that after testing were most appropriate. Other factors, which could not be defined by simple variables and which have not therefore been considered, may have been involved. The formulae included powers of V, E, and S which could be handled easily by statistical means. Other mathematical forms of the variables might yield more accurate relationships but would have been excessively difficult to use.

RELIABILITY

The formulae were developed using correlation coefficients and it is therefore possible to calculate the variance due to regression or, in other words, the extent to which the formulae explain the differences in trip generation between one subsector and another. Table 21 shows the formulae and the percentage variance accounted for by each. The remaining variance is of course unaccounted for by the formulae and is due to unknown factors.

At first sight the results shown are disappointing, as the percentage variance explained varies between 55 and six and the unexplained variance may be as high as 94 per cent. Nevertheless, other statistical tests showed the formulae to be significant in all cases at the five per cent level and in many cases they were significant at the one per cent level or better.

As was indicated above, the formulae may often give an indifferent prediction of the traffic generated for *individual* subsectors. Since the formulae are required to predict trips generated by large groups of subsectors, considered collectively, it was more important to test this reliability when applied to such groups. This was done for two groups, one of eight and one of seven subsectors. For each group the 1959 travel was calculated from the formulae and compared with data obtained from the surveys. Table 22 shows the results obtained for 'Total Trips'. Statistical tests were not applied to these results but inspection shows that the two sets of figures agree closely. This comparison was continued

TABLE 23

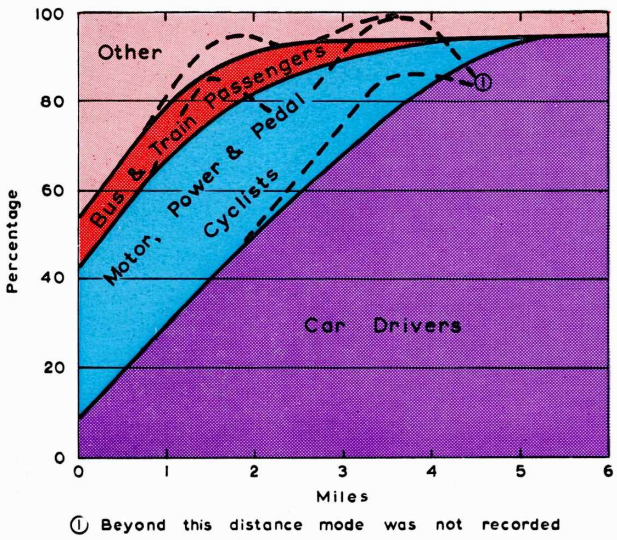
TRAVEL TO THE CENTRAL TRAFFIC DISTRICT (12 HOURS) 1959:
SUMMARY OF METHODS USED TO RELATE OBSERVED TRAVEL TO THE CHOSEN VARIABLES:* BY PURPOSE

SYMBOL	TRIP PURPOSE	PERSON TRIPS (FROM INTERNAL SUBSECTORS ONLY)		TYPE OF RELATIONSHIP DETERMINED
		Number	*Percentage*	
T_{tw}	To Work—first trip ..	24,127	38.7	Formulae
T_{twl}	To Work—after lunch ..	4,409	7.1	Graphical
T_{sch}	To School	1,460	2.3	None—Direct numerical estimate made when required.
T_b	Business trips:			
	Other work and Firm's ..	10,847		
	Business *Less* lunch ..	−4,409		
	trips (shown separately)	6,438		Formulae
	Plus Private Business and ..	+8,407		
	change of Travel Mode	14,845	23.8	
T_s	To shop	11,102	17.8	Formulae
T_r	To social (etc.) purpose: ..			
	For Social and Recreational purpose	2,193		
	Plus For Meals	+583		
	To Serve Passengers ..	+461		Graphical
		3,237	5.2	
T_h	To home:			
	From work	1,460		None—Direct numerical estimate made when required.
	From school	798		
	From other purposes ..	929		
		3,187	5.1	
	TOTAL PERSON TRIPS ..	62,367	100.0	
T_{tv}	Trade Vehicle Trips to Central Traffic District ..	6,464†	—	Formula

* Variables used were Average valuation of residential improvements (V): Total employment (E): Commercial employment (S): Distance from Cathedral Square (centre of Central Traffic District) (D).
† Vehicle trips only.

separately for all trip purposes and modes of travel with results of similar accuracy to those for 'Total Trips' (Table 51 in Appendix H).

A further practical check was applied. Trips to the Central Traffic District in 1980 have been calculated from those occurring in 1959 by applying, through the formulae, the effects of anticipated suburban changes. Amongst the pre-



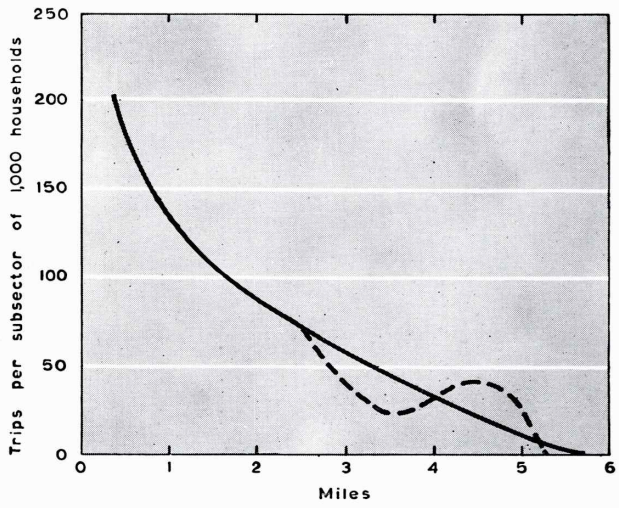


Fig. 53. TRIPS TO CENTRAL TRAFFIC DISTRICT, 1959: RETURN TO WORK AFTER LUNCH. The upper diagram shows each mode of travel as percentage of total travel, by distance from Central Traffic District: actual percentages (dotted lines) have been averaged. The lower diagram shows number of trips per 1,000 households, by distance from Central Traffic District: actual figures (dotted line) have been averaged.

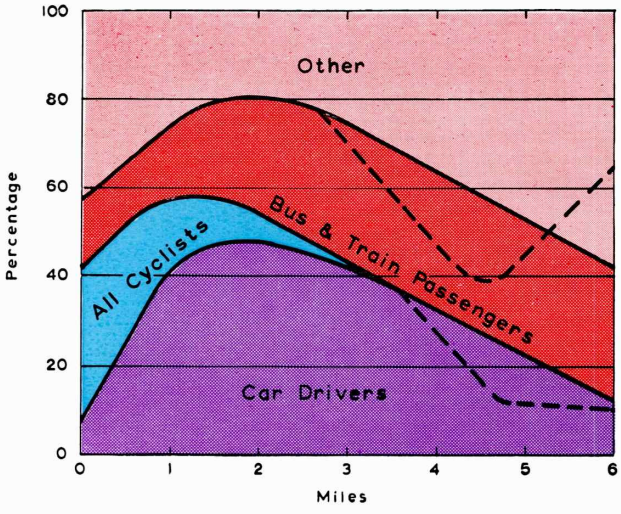
dicted data thus derived are estimates for journeys to work in the Central Traffic District.The total of trips to work agreed closely with predictions made quite separately as to the amount of employment which would exist within the central area.

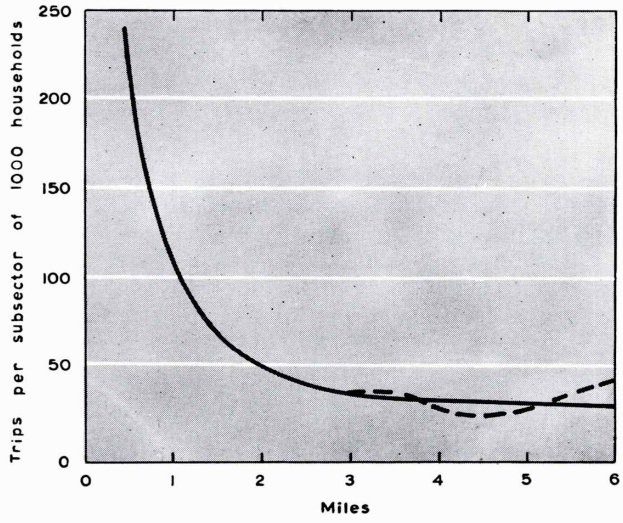
NON-FORMULAE TRIPS

As will be seen from Table 23, formulae were not derived for two purposes, namely 'Return to Work in Central Traffic District After Lunch' and 'Social and Recreational Purposes in Central Traffic District'. These formed only seven and five per cent respectively of total travel and for neither was it thought necessary to derive formulae. Instead a graph was prepared for each, relating total observed travel to distance from the centre of the Central Traffic District, Cathedral Square. A further graph was prepared in which each of the different modes of travel was related to distance (Figs. 53 and 54).

The graphs were plotted in terms of trips per

Fig. 54. TRIPS TO CENTRAL TRAFFIC DISTRICT, 1959: SOCIAL AND RECREATIONAL PURPOSES. The upper diagram shows each mode of travel as percentage of total travel, by distance from Central Traffic District: actual percentages (dotted lines) have been averaged. The lower diagram shows number of trips per 1,000 households, by distance from Central Traffic District: actual figures (dotted line) have been averaged.





1,000 households and may be used for prediction of future travel in the same manner as formulae. In fact the graphs may be regarded as exactly equivalent to the statistically derived formulae but derived by simpler methods. This simplification is justified by the lower significance of these travel purposes.

Two other trip purposes, namely 'To Home in Central Traffic District' and 'To School in Central Traffic District' have not been dealt with by statistical or empirical derivation of formulae. These account for five and two per cent respectively of the total travel to the Central Traffic District and it was considered that forecasting of their future could, with sufficient accuracy, be done by subjective estimate. Such subjective estimates would, of course, be based upon the present numbers for those types of trip purposes.

1980 FORECAST

This account of the derivation of travel formulae and graphs has been pursued in detail and at the cost of some repetition. This has been done because of its great importance to the preparation of 1980 forecasts. The formulae and graphs relate 1959 travel to employment, valuations, and distances of subsectors in 1959. New predictions can be made for these variables and a means is then created of forecasting travel for 1980, or other dates. Since, however, the formulae and graphs were derived for 1959 data for all the suburban subsectors collectively, they can only give accurate 1980 estimates on that basis; that is, a formula cannot be relied upon to give an accurate forecast of future travel to and from any individual subsector. This is a limitation which must be considered.

In the development of a transportation plan for 1980 it is essential to assess the road system in terms of 1980 traffic, and therefore it is necessary to know how much traffic will seek to use each of the more important roads. To do this, travel, determined as trips originating in all suburban subsectors, must be converted into traffic between particular pairs of subsectors.

It is desirable wherever possible to have accurate predictions of travel for individual subsectors and this the formulae cannot be completely relied upon to give.[3] This condition must be accepted for subsectors, such as those on the margins of the city, which are likely to alter greatly in character as a result of urban expansion and internal change during the forecast period; for these, the formulae or graphs derived from the collective data of 62 subsectors and localities must be used. The travel estimates, thus made, will sometimes be higher and sometimes lower than those actually occurring in 1980 but the cumulative effect should be sufficiently accurate. In a few specific cases other methods had to be used. For example, subsector 04, which contained considerably less than 1,000 households and was devoted mainly to industry, could confidently be expected to develop until 1980 by industrial expansion only; and its 1980 traffic could be better estimated by a consideration of the gain in industrial employment over the period. In this type of forecast it may be assumed that future travel will be in direct proportion to the increase in the number of the households (H) or the increase of total employment (E) of a subsector.

SUBURBAN TRAVEL

Travel to the Central Traffic District has been forecast directly from available data. The forecast for travel between suburban subsectors is, however, deduced from a study of subsector trip generation. Trip generation is used in a different sense to that of the term travel although they are obviously related phenomena. The distinction is worthy of redefinition.

A very important football match at Lancaster Park will generate trips to the sports ground and increase the traffic on most roads in Canterbury. It may be easier and more accurate to estimate the trips generated than to attempt to estimate the increased travel upon particular roads between particular hours. Considerations of this kind have led to the use of trip generation for the present estimate; the need to limit the first consideration to trip generation arises from the great amount of change in land use and economic activity and the consequent effects on the generation of trips. These changes may be so profound as to alter the whole travel patterns of the future. It is therefore

[3] For reasons given above in 'Limitations of the Formulae'.

TABLE 24

SUBURBAN SUBSECTOR TRIP GENERATION (12 HOURS) 1959: TRIPS TO WORK AFTER LUNCH PER 1,000 HOUSEHOLDS

ZONE	DISTANCE FROM CITY CENTRE (IN MILES)	NUMBER OF PERSON TRIPS PER 1,000 HOUSEHOLDS				
		Car Drivers	*Cyclists*	*Bus and Train Passengers*	*Other*	*Total*
I	0.5—1.0	50	65	20	65	200
II	1.1—2.0	100	80	10	10	200
III	2.1—3.0	100	50	10	15	175
IV	3.1—4.0	100	25	10	15	150
V	4.1—5.0	75	10	5	10	100
VI	5.1—6.0	75	10	5	10	100

difficult and inaccurate to estimate future travel from that now existing. Trip generation, based upon anticipated land uses, will give a better estimate.

However, there is one disadvantage that follows from the above method of working, namely, the trip generation estimates must be changed into travel estimates, that is, the former estimates must be distributed as travel between pairs of subsectors. This involves the making of further assumptions and is thereby a source of additional error but in the method used in the present study this disadvantage is overcome to some extent by assuming that the same basic pattern of attraction that occurred between pairs of subsectors in 1959 will exist in 1980, although the magnitude of the travel between pairs of subsectors will be increased in relation to the growth of trip generation of all subsectors, considered collectively.

THE FORMULAE

In developing formulae for travel to the Central Traffic District, a total of 57 subsectors and five external localities were considered as contributing an element of traffic simultaneously to one particular subsector, the Central Traffic District. In developing formulae for the trip generation of suburban subsectors, the study was made of 57 subsectors generating the total of trips simultaneously, regardless of destination.

The subsector characteristics chosen as variables for derivation of formulae and graphs and the modes of travel were the same as in the Central Traffic District study. The trip purposes chosen for separate analysis are also similar (Table 26).

The development of formulae followed precisely the methods already described in the Central Traffic District study and the results obtained are subject to the same limitations of accuracy and application. Once again a number of combinations of purpose and mode were found not to warrant the derivation of statistical formulae and these were dealt with graphically or by tabulating data.

NON-FORMULAE TRIPS

To Work After Lunch (T_{twl}) is a small group and comprises only about three per cent of total trips generated. As a basis for estimating trips for this purpose, a table was constructed of the 1959 situation expressing the number of trips as a ratio of 1,000 households and according to distance from the centre of the city. These ratios form a table which was used to estimate 1980 trips, given the number and distribution of households (Table 24).

From Shopping and Private Business (T_{fsp}) is a convenient combination of a number of associated or similar travel purposes. It is a small group involving only about eight per cent of total trip generations. It can, however, assume larger proportions in certain subsectors where there are many shops grouped to form larger commercial

centres. Initially it was desired to graph trip generation against commercial employment (as variable), but some subsectors failed to fit this simple approach (Fig. 55). These subsectors were found to be those that contain significant employment opportunities in addition to commerce and, in forecasting trip generation, allowance was made for this by reducing the value for commercial employment (S). In other words, it appears that persons entering an area to work may also shop in that area and that fewer trips are made than would be supposed from separate consideration of the opportunities to work and to shop. This effect was observed where there are adjacent industrial areas, particularly for Sydenham and, to a lesser extent, for Riccarton and Addington. Other subsectors without a similar relationship to industry did not display this tendency and all fitted reasonably well to a single graph. For

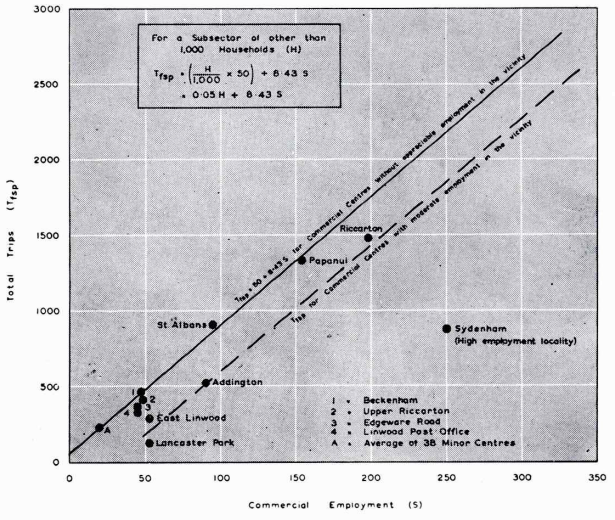


Fig. 55. SUBURBAN TRIP GENERATION, 1959: FROM SHOPPING AND PRIVATE BUSINESS. The relationship of number of trips from shopping and private business and amount of commercial employment in shopping centres in 1959 can be fitted in most cases to the upper straight line which is represented by the simple formula along the line. Inset is the formula for cases where the number of households in a subsector varies from 1,000. Other commercial centres with moderate employment in their vicinity in addition to commerce, fit the lower line; Sydenham is distinct as a high employment area.

future forecasting it is necessary to bear in mind that the statistical data for Sydenham differs somewhat from that for Addington and Riccarton, and that the graph drawn for these three areas is less reliable than the one drawn for all the remaining subsectors. Moreover, future increases of general employment near other suburban shopping centres may occur. The predictions obtained from these graphs were critically examined and given subjective adjustment where this appeared to be warranted.

Trips from Social-Recreational and Miscellaneous Purposes (T_{fr}) form another small group comprising approximately six per cent of the total trips generated, but it also varies greatly from subsector to subsector and is not suitable for prediction by simple formulae unless used with discrimination, as, for example, in subsectors having a community or neighbourhood centre which includes hotels and cinemas, or in subsectors having golf courses or beaches. These areas may generate many trips. For prediction purposes subsectors may be grouped according to the importance of recreational facilities within them (Table 25).

For 1980, subsectors were allotted to one of these categories and trips predicted on the basis of trip generation per 1,000 households in 1959. Adjustments were made for any anticipated changes in the location of recreational facilities.

From Home to School (T_{tsch}) is numerically a moderately large group (11 per cent of total trips generated) but consists largely of local travel by cycling or walking. School trips were largely ignored because they are basically local and non-vehicular. School trips by bicycle were allowed for in assessing street capacity but, over all, future vehicular possibilities cannot have a very significant impact on the general problem of traffic. Where predictions are necessary, estimates can be made on the basis of the number of households and the educational facilities expected to be within each subsector.

Trips from school (T_{fsch}) concern a group of similar size and the same principle applies.

Trade Vehicles (T_{tv}) were not subjected to statistical analysis in order to determine formulae,

TABLE 25

SUBURBAN SUBSECTOR TRIP GENERATION (12 HOURS) 1959: TRIPS FROM SOCIAL-RECREATIONAL AND MISCELLANEOUS PURPOSES PER 1,000 HOUSEHOLDS

SUBSECTOR CATEGORY	*Number of Subsectors*	*Range of Person Trips per 1,000 Households*	*Average Number of Person Trips Per 1,000 Households*
Subsectors without special recreational etc. attractions ..	44	Less than 400	215
Subsectors with special recreational etc. attractions ..	14	Less than 700	540

as a close relationship was found by graphic methods to exist between the number of trade vehicle trips and the amount of local employment. This graph exhibits a straight line relationship between employment and trade trips and can of course be represented by a simple formula (Fig. 56). It will be noted that the point representing the data for Sydenham lies well above this line and the points for Woolston and Burnside–Airport are well below.[4]

FORMULAE TRIPS

Table 26 shows, for a 12 hour period, the more important groupings of trip purposes and the numbers of trips which were analysed. It also shows whether formulae or graphs were obtained for such trip purposes or whether subjective estimates were required for 1980 predictions.

Table 27 gives details of the formulae obtained by regression on logarithms to represent present trip generations. It can be seen that the percentage of variance explained is rather better than for the formulae derived from travel to the Central Traffic District. It may be noted that employment is the only variable which enters into nearly all formulae derived. Distance becomes of significance only with cycle trips and with the miscellaneous ('other') trips which include walking.

[4] Sydenham contains the main railway goods sheds and the premises of a number of carriers and road haulage contractors: the reasons for the positions of Woolston and Burnside-Airport are not clear although the Woolston area appears to have been poorly reported in the surveys.

USE OF FORMULAE

Three difficulties are apparent in the use of these formulae as a basis for estimation of 1980 trip generation. The first concerns the Sydenham area which has already been discussed in relation to trade vehicle trips and shopping–private business trips. The formulae, which accurately predicted these trips for subsectors considered collectively, did not do so for particular subsectors, such as Sydenham, in which trade and industry are particularly important.

The second difficulty is of more general concern. Discussion will be recalled as to when formulae

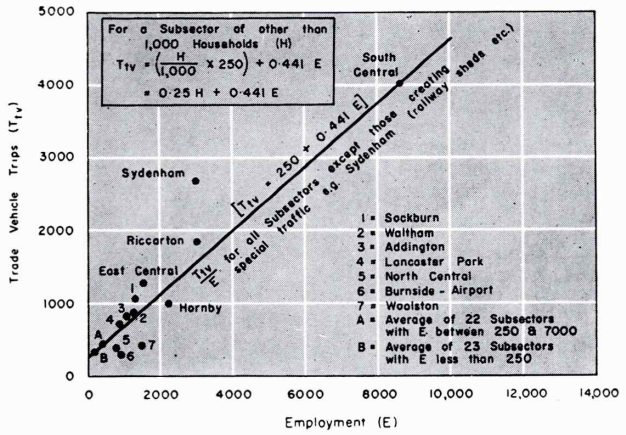


Fig. 56. SUBURBAN TRIP GENERATION, 1959: TRADE VEHICLES. The relationship of number of trade vehicle trips (12 hours) and amount of employment in 1959 can be generally fitted to the straight line which is represented by the simple formula along the line. Inset is the formula for cases where the number of households in a subsector varies from 1,000.

TABLE 26

SUBURBAN SUBSECTOR TRIP GENERATION* (12 HOURS) 1959: SUMMARY OF METHODS USED TO RELATE OBSERVED TRIP GENERATION TO THE CHOSEN VARIABLES**: BY PURPOSE

SYMBOL	TRIP PURPOSE	PERSON TRIPS		TYPE OF RELATIONSHIP DETERMINED
		*Number***	*Percentage*	
T_{twf}	To work—first trip	59,458†	22.8	Formulae
T_{twl}	To work—after lunch	8,518	3.3	None—Present tabulated values provide a guide for future estimate.
T_{fw}	From work—last trip	31,534†	12.1	Formulae
T_{ow}	Other from work trips including home for lunch	22,007	8.4	Formulae
T_{tspr}	From home to shopping, private business, and miscellaneous (including to meal, to serve passengers, etc.)	42,901	16.4	Formulae
T_{fsp}	From shopping, private business ..	19,648	7.5	Graphical
T_{fr}	From social-recreational and miscellaneous (including from meal, serving passengers, etc.)	16,526	6.3	None—Estimate necessary—Affected by type and size of recreational facilities
T_{tsch}	From home to school	28,799	11.0	None—Estimate necessary—Depends on educational facilities in subsector.
T_{fsch}	From school	31,789	12.2	None—Estimate necessary—Depends on educational facilities in subsector.
	TOTAL PERSON TRIPS	261,180	100.0	
T_{tv}	Trade Vehicle trips from suburban subsectors	32,571††	—	Graphical

* In addition to the Central Traffic District, subsector 05 (Hagley Park) is excluded from this Table.

** Variables used were Average valuation of residential improvements (V): Total employment (E): Commercial employment (S): Distance from Cathedral Square (centre of Central Traffic District) (D).

*** Includes trips terminating in the Central Traffic District.

† T_{fw} has considerably fewer trips than T_{twf} because the opportunities for employment within these subsectors are less than the employable population part of which goes to the Central Traffic District.

†† Vehicle trips only.

should be used to predict future travel to the Central Traffic District, and when it would be preferable to calculate future travel by other methods. Bearing in mind that some subsectors may be expected to change greatly and others little as travel generators, it was concluded that both methods ought to be considered. In general, use of the formulae was preferred. Travel estimates by the consideration of special circumstances were made only for subsectors having unusual characteristics. The same approach was used in the prediction of future trip generation of suburban subsectors.

The third difficulty is in the case of some subsectors which were drawn in 1959 to include 1,000 households but which will in 1980 contain

TABLE 27

SUBURBAN SUBSECTOR TRIP GENERATION* (12 HOURS) 1959: TRIP FORMULAE BY PURPOSE AND MODE

TRIP PURPOSE AND MODE	TRIP FORMULA PER 1,000 HOUSEHOLDS	PERSON TRIPS		PERCENTAGE OF VARIATION EXPLAINED	REMARKS
		Number†	*Percentage*		
To Work—first trip					
Total ..	$T_{twf} = \frac{2209}{E^{0.13}}$	59,458	100	32	
By Car ..	$t = \frac{1.012V^{0.90}}{E^{0.16}}$	20,731	34.8	65	
By Cycle ..	$t = \frac{1250}{E^{0.15}D^{0.4}}$	22,077	37.1	23	
Bus and Train	$t = 176$	10,029	16.9		Subsector average is best estimate.
Other ..	$t = \frac{388}{E^{0.17}D^{0.25}}$	6,621	11.2	22	
From Work—last trip					
Total ..	$T_{fw} = 1.677E^{0.90}$	31,534	100	93	
By Car ..	$t = 1.991\ E^{0.75}$	12,770	40.5	87	
By Cycle ..	$t = 0.201\ E^{1.06}$	12,280	39.0	41	
Bus and Train	$t = 0.0036\ E^{1.41}$	3,225	10.2	55	
Other ..	$t = 0.022\ E^{1.17}$	3,259	10.3	39	
Other from Work Trips					
Total ..	$T_{ow} = 2.956\ E^{0.77}$	22,007	100	88	
By Car ..	$t = 5.181\ E^{0.62}$	14,837	67.4	81	
By Cycle ..	$t = \frac{0.139\ E^{0.94}}{D^{1.3}}$	3,344	15.2	44	
Bus and Train	$t = \frac{478000\ E^{0.58}}{V^{1.92}}$	786	3.6	31	
Other ..	$t = 1.148\ E^{0.61}$	3,040	13.8	27	
From Home to Shop, Private Business, etc.					
Total ..	$T_{tspr} = 11.37V^{0.56}$	42,901	100	21	
By Car ..	$t = 0.88\ V^{0.74}$	13,891	32.4	15	
By Cycle ..	$t = 93$	5,280	12.3		Subsector average is best estimate.
Bus and Train	$t = \frac{1270}{E^{0.32}}$	11,423	26.6	13	
Other ..	$t = 214$	12,307	28.7		Subsector average is best estimate.

* In addition to the Central Traffic District, subsector 05 (Hagley Park) is excluded from this Table.

† Includes trips terminating in the Central Traffic District.

two, three or more times as many households and should therefore be subdivided for the purposes of making the 1980 travel forecasts. The method which has been adopted to turn trip generations into travel between subsectors, does not allow this to be done. The final travel forecast therefore, includes as travel between subsectors some journeys which ought to be shown as travel within subsectors. It is anticipated that this effect will be insignificant and will be confined to the peripheral suburbs, which are not subject to large volumes of traffic.

EXTERNAL TRAVEL

The trip formulae discussed above are those which 'explain' 1959 trips between internal subsectors and the Central Traffic District, and total trip generation of internal subsectors. Each of the latter trips must, of course, have a second terminal point and this may be within the Central Traffic District, within the remainder of the Internal Area, or within one of the external localities. At this point in the argument, the total trip generation of each internal subsector is known for 1959 and is predictable for 1980; that part representing movement to and from the Central Traffic District is also known or predictable. What is now required is the number of trips generated to and from external localities. Once this is known, subtraction from the total trip generation of each internal subsector, of trips to and from the Central Traffic District and to and from the External Area, will give the number of trips which occur wholly within the suburban subsectors (within the Internal Area, excluding the Central Traffic District). Having obtained the movements which occur wholly within the suburban subsectors for 1959 and 1980, it is possible to calculate a growth factor for this travel. Trip generation of external localities is therefore important as a step in the determination of travel within suburban subsectors, as well as being significant in itself.

Various procedures were adopted for external localities. In the first place localities were considered to be capable of three significantly different groupings. The first group comprised localities which are near, and develop relatively heavy traffic, to Christchurch, for example Lyttelton, Halswell, Kaiapoi, Belfast. For these localities the increases are likely to be not solely in proportion to their population and employment growth. Therefore each of the localities was evaluated separately and very carefully. The second group comprised the remaining localities of Canterbury, and the third group was the remaining localities of the South Island. For the more distant localities the population growth alone was considered to give an adequate assessment of trip increases. Moreover the importance of these localities as generators of Christchurch traffic was not considered to warrant the calculation of separate growth factors for each locality. Instead a prediction was made of population growth for the whole of the remainder of Canterbury and this one growth factor was used for all the second group of localities. A single growth factor was also calculated for all the localities of the third group.

Future travel from an external locality to any particular internal subsector can be determined by applying to 1959 traffic, the growth factors described above and a factor to represent the change in importance of the internal subsector relative to the Internal Area as a whole. This last point is especially important in relation to the Central Traffic District for this, it is known, is likely to grow more slowly than the remainder of the Internal Area. Theoretically, an accurate calculation of traffic between a particular external locality and the Central Traffic District (or some other internal subsector) should always take account of this change in importance of the internal subsector. In fact this was not done for all the studies recorded here. For example, some external localities (in particular Belfast, Kaiapoi, Rangiora and Governors Bay) have population concentrations with easy and direct access to the Central Traffic District. This affinity is expected to continue and traffic to the centre was assumed not to decline, relatively, for these localities. Though the more distant parts of Canterbury and of the South Island will produce only a limited trip generation to Christchurch, this is expected to be mainly associated with the Central Traffic District. The method used for these localities assumes

that traffic will continue to be distributed within Christchurch according to present proportions.

Some individual adjustments of method were made for the localities of Lyttelton, Halswell and Kaiapoi where special problems exist. Brief mention must also be made of through traffic, that is traffic from one external locality to another, which passes through Christchurch. This traffic is of small volume in relation to other categories and does not warrant any great refinement of method. What has been done is to calculate growth factors for each external locality and obtain their arithmetic mean. This mean, applied as a growth factor to 1959 traffic, is assumed to predict 1980 through traffic with sufficient accuracy.

DISTRIBUTING TRIPS

The distribution of trips generated in 1980 between pairs of subsectors (excluding travel to the Central Traffic District) poses a specific problem, a simple example of which is illustrated in Figure 52. It is not possible to derive a formula, and thus obtain a simple and unique distribution of trip generation, because the growth of traffic between a particular pair of subsectors will be affected by changes of trip generation in many other subsectors. The method used, which involves solution by successive approximation, was that developed by Fratar and is described in outline in Appendix E. Since it requires the simultaneous use of growth factors, calculated in respect of each of the many subsectors, it results in most complex and tedious calculations and was only made possible by the availability of an electronic computer.

SUMMARY

The account of the development of formulae and graphs to explain 1959 travel and to predict 1980 travel—as yet on the basis of 1959 figures for vehicle ownership—has been given in some detail because of their great importance. The prediction of future travel used, in various parts, all the logical tools of mathematics; for other parts subjective estimates have been considered sufficiently accurate. Such extremes make strange companions and a cursory treatment might leave wrong impressions as to the quality of the thinking and endeavour which lie behind the estimates. It has been the aim in this full treatment to show that careful discrimination lies behind the choice of methods. In most cases the best scientific methods have been used within the limited resources available and less rigorous methods have been adopted only for trip purposes and modes of lesser importance. Subjective estimates have been

TABLE 28

GROWTH FACTORS OF TRAVEL (EXCLUDING SCHOOL TRIPS) 1959-1980, ON 1959 VEHICLE OWNERSHIP BASIS: BY TRAVEL MODE

TRAVEL MODE	INTERNAL TRAVEL*			EXTERNAL TRAVEL				INTERNAL PLUS EXTERNAL TRAVEL		
					Other					
	To C.T.D.†	*Other*	*Total*	*To C.T.D.†*	*Inward*	*Through*	*Total*	*To C.T.D.†*	*Other*	*Total*
Car Driver ..	1.460	1.900	1.716	1.439	1.924	1.832	1.754	1.457	1.903	1.721
Cyclist ..	1.204	1.704	1.491	Not covered by Survey				—	—	—
Bus and Train ..	1.405	1.732	1.499	1.589	1.745	—	1.682	1.420	1.735	1.523
Others ..	1.513	1.656	1.594	1.335	1.931	1.840	1.707	1.474	1.727	1.621
TOTAL TRAVEL OF PEOPLE ..	1.393	1.783	1.598	1.429	1.893	1.836	1.721	1.397	1.798	1.613
TRADE VEHICLES	1.316	1.821	1.647	1.482	1.756	1.410	1.674	1.333	1.811	1.651

* Details of subsector growth factors for internal travel by travel mode are given in Table 52 in Appendix H.
† Central Traffic District.

made where the paucity of data left no alternative.

Travel to the Central Traffic was predicted separately by applying percentage increases to the 1959 values. For all other subsectors of the Internal Area and for all localities of the External Area, the conversion of trip generation to travel was made by the Fratar method and depends upon the use of subsector growth factors. These growth factors, at this stage on the basis of 1959 figures for vehicle ownership, are obtained by the comparison of 1959 values with those of 1980, the latter derived from the formulae, graphs and other relationships. The growth factors are shown in Table 28.

VEHICLE INCREASES

The discussion of procedure for estimating 1980 traffic has so far not included changes in the ratio of vehicles to population, or the utilisation of vehicles. In Table 28 the growth factors of travel from 1959 to 1980 by travel mode have been determined by calculating travel for 1980 through the formulae, graphs and other relationships derived from the 1959 travel surveys. To the extent that those formulae favour the use of private cars for longer journeys, the figures reflect a higher car ownership index for 1980 than in 1959. However detailed estimates were made in Chapter Four of the increase in the ratio of cars per person and it was suggested that increased car ownership is itself a generator of additional traffic. It remains therefore to decide what account to take of this factor and what consequential adjustments may be necessary in the estimates for other modes of travel. To determine the adjustments, growth factors for population, employment, and vehicle ownership, from 1959 to 1980, have been derived from data presented in Chapter Four and Appendix H (Tables 46, 48 and 49); for travel, the growth factors in Table 28 are used.

Population within the Internal Area (growth factor for 1959-1980)	1.59
Employment within the Internal Area (growth factor for 1959-1980)	1.64
Total travel of people within Internal and External Areas (growth factor for 1959-1980	1.61
Total car travel within Internal and External Areas (growth factor for 1959-1980)	1.72*

The anticipated increase of vehicle ownership per capita for 1959-80 is:

Private cars 55% or growth factor of 1.55
Trade vehicles 33% or growth factor of 1.33

It could be assumed that the vehicle travel estimates should be additionally increased by these vehicle ownership factors, on the assumption that the increased ownership of vehicles is directly productive of additional vehicular travel at the expense of other modes. It was argued in Chapter Four that, other things being equal, other modes of transport, for example, public transport and cycles, will decline in importance with the greater role of motor cars.

Forecast growth of car travel due to urban changes	1.72
Increased ownership index of cars, factor is	1.55
Anticipated growth of car travel on this assumption is	2.66
Now for increase in population, factor is	1.59
Increased proportion of cars per person, factor is	1.55
∴ Increased car registration, factor is	2.46

The assumption made therefore leads to the conclusion that all cars will be subject to increased utilisation, viz:

$$\text{Increased utilisation factor} = \frac{\text{Growth of car travel}}{\text{Increased car registration}} = \frac{2.66}{2.46} = 1.08$$

It was considered unlikely that every car in 1980 would in fact be used more than those of 1959. Firm evidence on which to base this conclusion was not available but support came from various sources.

During the period 1948 to 1955 car registration in Washington D.C. increased by a factor of 1.96 while car trips increased in number by a factor of 1.89; that is, the average number of trips per car in 1955 was only 97 per cent of those made in

* This increase is significantly higher than the other growth factors because of the greater utilisation of private cars compared to other modes of transport.

1948.[5] In the United Kingdom a paper by Scott and Tanner of the Road Research Laboratory reports on traffic trends and vehicle milages over the period 1938 to 1960.[6] The years included periods of petrol rationing during and after World War II and the Suez Crisis, but, these apart, there was relatively small variation in the annual milage run per vehicle. Finally, New Zealand petrol sales statistics suggest a steady though slight increase in annual milage per car and this is in accordance with some trends in the United States. It is difficult to get conclusive evidence on this point for petrol sales are affected by such matters as horsepower and efficiency, which are difficult to take into account, and the possibility that trips are increasing in length as, for example, towns grow outwards. In summary then, there was little support for the conclusion that all cars in 1980 will be subject to increased utilisation.

For the present study it was assumed that vehicle utilisation is unchanged.

Population increase factor 1.59
Car ownership index factor 1.55
$\therefore$ Increased registration of cars factor
$1.59 \times 1.55 = 2.46$
Increase in car travel forecast by formulae etc. $= 1.72$
$\therefore$ Additional factor to be used to allow for increase of car ownership $\frac{2.46}{1.72} = 1.43$

Thus for forecasts of car travel within the Internal Area, travel predictions given by the travel formulae have been further increased by a factor of 1.43.

Discussion earlier in this chapter has shown the difficulties of deriving satisfactory travel formulae to fit the data of trips generated in the External Area. The method of forecasting adopted for these localities was based mainly upon population growth and has not reflected, in any way, the increase of the motor vehicle ownership index. The full value of 1.55 for the growth factor of private cars has therefore been applied as an additional factor for all external trip generation.

Referring now to trade vehicles, the growth forecast by formula agrees closely with the expected increase of employment. However an increase of trade vehicles per capita is to be expected as higher standards of service to customers occur and a higher degree of mobility is sought by tradesmen. It is therefore considered reasonable to apply in full the factor which represents the increase of trade vehicles per head of population. This factor is 1.33 for the period 1959-1980 and represents increased trading due to higher productivity and to an increase in the standard of living.

It is possible that the utilisation of private cars will vary with trip destination, depending upon traffic and parking difficulties likely to be encountered upon various routes. For example, a housewife might always take a car for suburban shopping but prefer bus transport when shopping in the city centre. In that event a lower factor should be used when expanding trip predictions for the central area, and this could be effected by applying different factors to take account of the increase in car ownership. This is a most difficult point on which to decide. If persons are frustrated by traffic or parking difficulties near the city centre, they may transact their business at a suburban centre which is more readily accessible to private cars. The latter is not in the interests of business and commercial houses with premises in the central business district and may not always be in the best interests of the community but the cost of providing improved traffic and parking facilities will be a heavy one. Town and traffic planning now exists in nearly all developed countries and this suggests a widely held belief in the efficacy of such planning. If a community, and Christchurch in particular, believes in the overall desirability of working to an agreed plan, it must be prepared to pay the costs. If it is not so prepared, then many assumptions inherent in a study such as this become futile.

In this study it is assumed therefore that conditions of traffic and parking in the Central Traffic District do not cause frustration to

[5] G. E. Brokke and W. L. Mertz: 'Evaluating Trip Forecasting Methods With an Electronic Computer', *Highway Research Board Bulletin* No. 203, 1958.
[6] J. R. Scott and J. C. Tanner: 'Traffic Trends and Vehicle-miles in Great Britain, 1938-1960', *The Surveyor*, May, 1962.

TABLE 29

TRAVEL FOR 24 HOUR PERIOD 1959 AND 1980: SUMMARY OF VEHICLE TRIPS*

AREA	*1959*	*1980*	*Percentage Increase*
Central Traffic District			
Total moving to and from	88,005	181,767	107
Part of total that is external	8,245	18,500	124
Remainder of Internal Area			
Total movements except those to and from Central Traffic District	134,588	356,270	165
Part of total that is external	16,913	47,501	181
Total Internal Area			
Total movements in the Internal Area ..	222,593	538,037	142
Part of total that is external	25,158	66,001	162

* Total trips by private cars, taxis and trade vehicles, excluding trips passing through the Internal Area without stopping; adjusted for 10 per cent Transverse Screen Line deficiency, and car and trade vehicle ownership growth factors.
See Tables 53, 54 and 55 in Appendix H for details by subsector and locality.

travellers and that the increase of vehicle ownership will generate additional traffic to the central area as it does to other internal areas.

1980 TRAFFIC

The examination of the various methods of estimating future travel and traffic, of the underlying assumptions, and of the limitations in application is now complete and it is possible to present the results expected for the design year of 1980. The results are in Table 29, which is a summary of movements between pairs of subsectors, and are also portrayed in terms of desire lines of movement (Figs. 57, 58, 59, 60 and 61). Detailed figures by subsectors are given in Appendix H (Tables 53, 54 and 55).

The figures, actual for 1959 and predicted for 1980, depend upon the 1959 travel surveys. After adjustment, these showed good agreement with the traffic surveys, as seen in Chapter Three, although there remained a deficiency of 10 per cent between the vehicular traffic crossing the Transverse Screen Line as reported in the travel surveys and that which was observed to do so in the traffic surveys. It will be recalled that, by definition, trips of less than half a mile or not involving movement from one subsector to another were deliberately omitted. In consequence the travel surveys accounted for fewer vehicle movements than were counted at the check line. This was corrected by applying a 10 per cent adjustment. Moreover, the traffic surveys themselves needed adjustment before being used because they were carried out for a 12 hour day only, and it was desired to make the 1980 estimates in terms of a 24 hour day. The 12 hour counts of vehicles have therefore been increased by a factor of 1.25.[7] The final figures have been further increased, by a factor of 1.43 in respect of journeys by private car and 1.33 in respect of journeys by trade vehicles, to allow for increased vehicle ownership.

Table 55 in Appendix H gives detailed data by localities for external traffic associated with the Internal Area. In this case a factor of only 1.2 has been used to convert the 12 hour traffic flow into an estimated 24 hour traffic flow.[7] This lower factor reflects the absence in the External Area of the cinemas, cafes and other attractions which bring a lot of traffic to the city centre. The Internal Area also contains some industry which has need of special shift workers and this encourages a greater amount of night time traffic.

Figures 57, 58, 59, 60 and 61 show desire lines of travel predicted for an average weekday in 1980. These maps are not strictly comparable

[7] The figures were derived from machine counts made of Christchurch traffic at the External Cordon Line (1.2) and at the Belt Cordon Line (1.25).

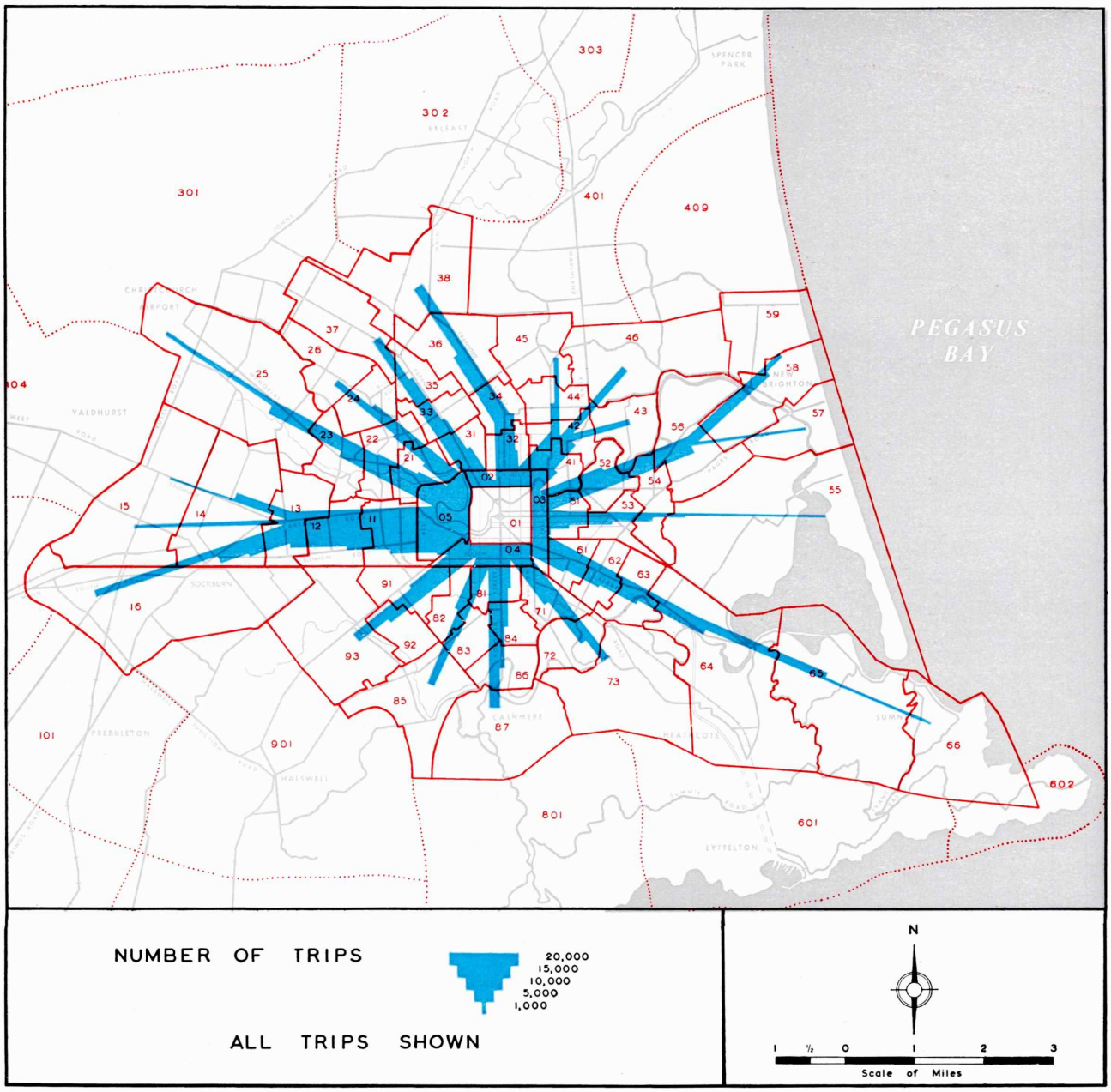


Fig. 57. Desire lines for private cars and taxis between the central traffic district and suburban subsectors, 1980. Travel for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

with the data of Table 29 because they cover the period 6.30 a.m. to 6.30 p.m. only, and even for this period it is not practicable to include all combinations of subsectors. Desire lines are not shown between subsectors for which the traffic is light and varying proportions of the traffic (in the order of approximately 20 per cent) are omitted from the maps for this reason.

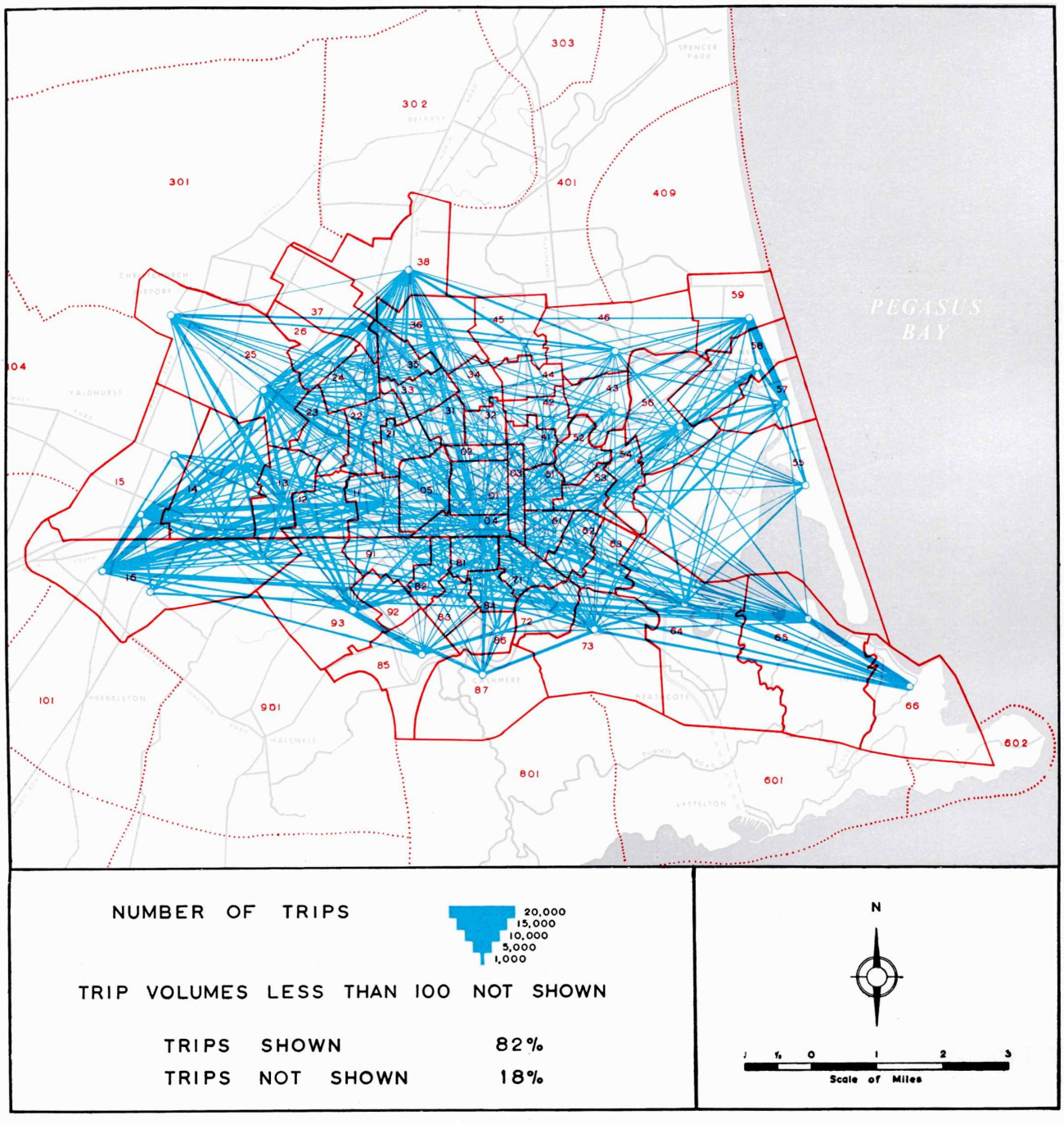


Fig. 58. Desire lines for private cars and taxis between suburban subsectors, 1980. Travel between internal subsectors (excluding the Central Traffic District) for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

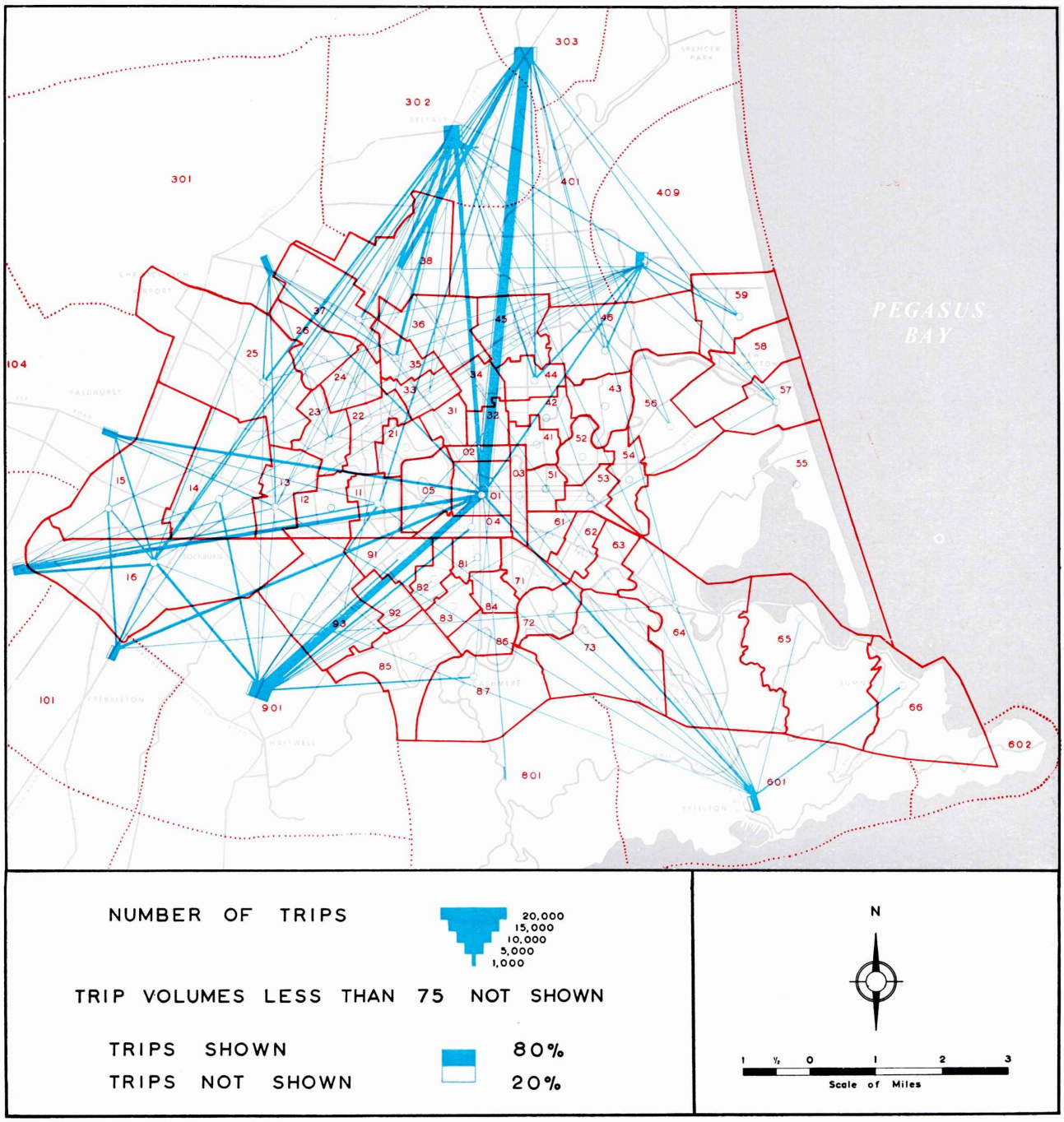


Fig. 59. Desire lines for private cars and taxis between internal subsectors and external area, 1980. Travel for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

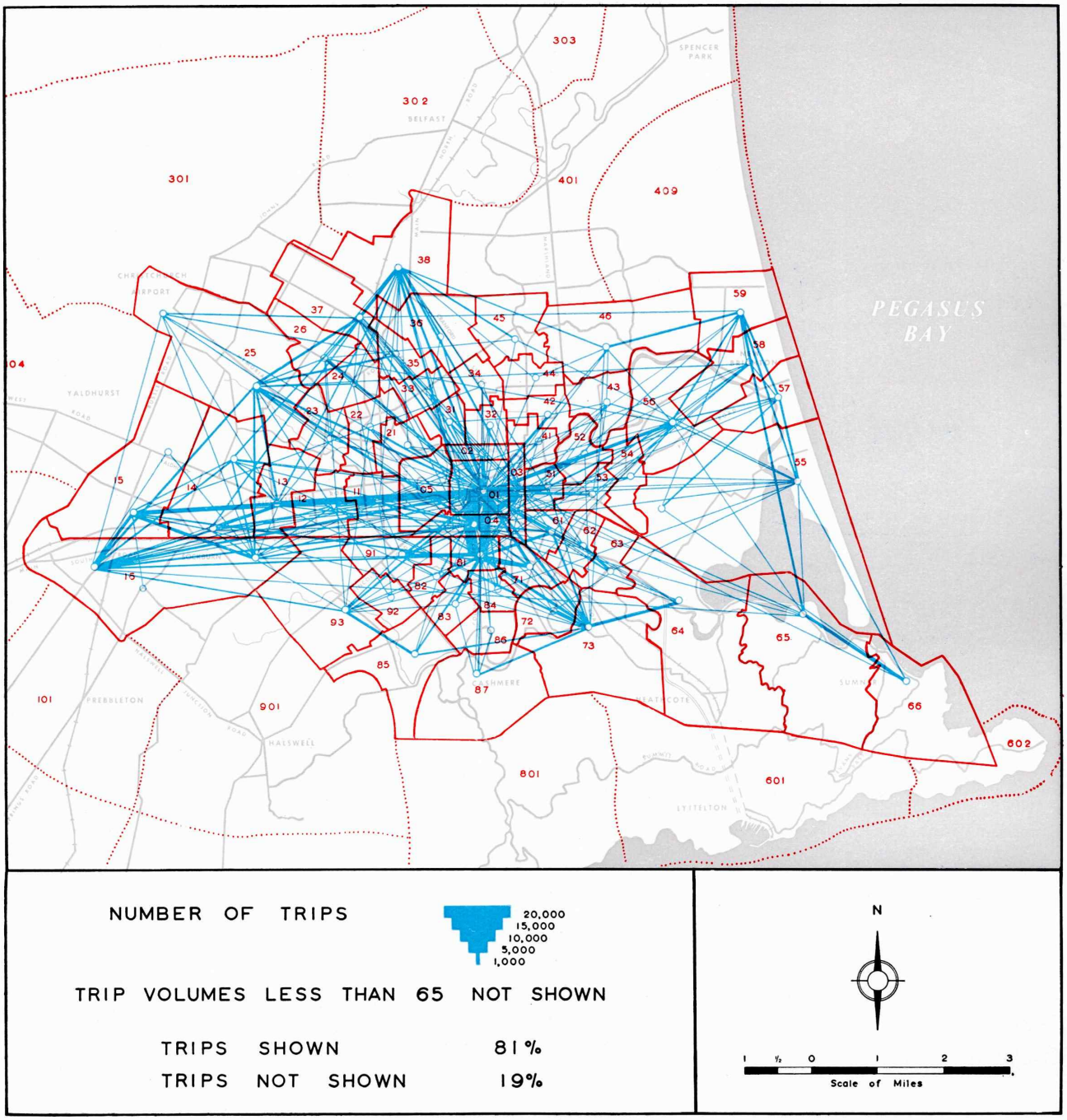


Fig. 60. Desire lines for trade vehicles between internal subsectors, 1980. Travel for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

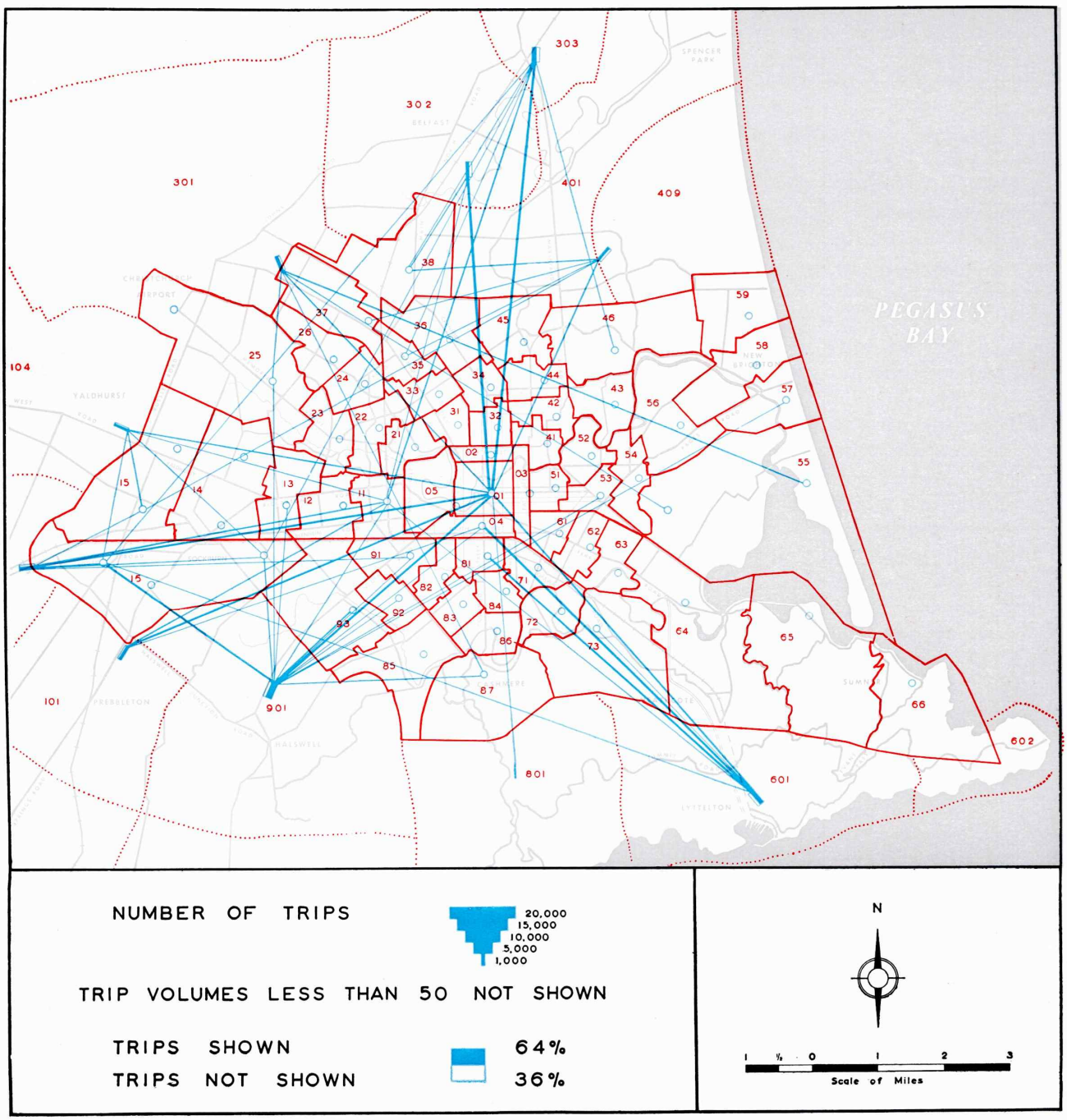


Fig. 61. Desire lines for trade vehicles between internal subsectors and external area, 1980. Travel for 12 hours (6.30 a.m.-6.30 p.m.) on an average weekday.

CONCLUSION

The tabulated movements of people and vehicles estimated for 1980, and the maps of desire lines of movement for various modes of travel between areas, reveal the size and nature of the broad problems that the transportation system of Christchurch will have to meet in 1980. The overall growth of traffic within the Internal Area is expected to increase by 142 per cent (Table 29) but the incidence of this upon the street system will vary greatly. This variation of incidence will be partly due to the relative reduction in importance of the Central Traffic District and the growth of outlying industrial areas. It will also be partly due to the differing amounts of urban development to be expected for the catchment areas of the various radials. Further, the traffic will make different impacts upon different parts of the street system because of the variations of reserve capacity which they now possess.

The Central Traffic District is expected to continue as the dominant traffic generator. The number of vehicle trips per 24 hour day, to and from this district, is expected to increase from 88,000 in 1959 to 182,000 in 1980, an increase of 107 per cent. Proportionally, traffic over the remainder of the Internal Area will have a greater increase, from 135,000 in 1959 to 356,000 trips per day in 1980, which represents an increase of 165 per cent. Traffic from the External Area to Christchurch is expected to increase at about the same rate—162 per cent—but the quantity of traffic will represent only 12 per cent of all the traffic within the Internal Area. The external traffic is in fact expected to increase from 25,000 vehicles per day in 1959 to 66,000 in 1980; about one third of that traffic will be bound for the city centre.

A comparison of the desire line maps for 1980, presented in this chapter, and those for 1959, presented in Chapter Three, reveals not only a very great increase in the volume of travel but also changes in its distribution in response to changes in the distribution of population and employment throughout the urban area. Both the detailed tables and the desire line maps describe only the origins and destinations of vehicle trips. There is no reference to the streets used by the vehicles in moving from one place to another. The next step, therefore, is to turn this data about the general lines of travel into volumes of traffic on the streets themselves. In this way the ability of the present street system to accommodate the traffic estimated for 1980 can be assessed.

CHAPTER SIX

The Traffic of 1980

THE LAST CHAPTER showed the patient processes whereby the movements of people and vehicles were forecast for 1980. It is intended now to examine the adequacy, or otherwise, of the present street system to carry 1980 traffic and to look at associated problems. It is worthwhile re-emphasising that the 1980 traffic forecast is necessarily approximate and the increases it foreshadows are likely to occur in some localities earlier, and in some later, than 1980. It is believed to show a reasonably accurate outline of the problems to be faced in twenty years' time and their locations.

ASSIGNING TRAFFIC

Before the forecasts can be used to assess the adequacy of particular streets and to prepare proposals for new works, it is necessary to assign traffic to particular routes and an explanation will now be given of this process and the need for it.

Consider two subsectors, say A and B in Figure 62, subsectors which may or may not be adjoining. The calculations described have determined the trips generated by each and from that the traffic, by modes, which flows between pairs of subsectors. No prediction has yet been made as to the proportions in which this traffic will use the alternative routes that are available. To make these predictions requires that further assumptions be made. For some road users a choice of routes may not exist or may be affected by overriding factors. Thus bus routes are prescribed by the appropriate management and are commonly arranged to suit the passenger traffic offering. Heavy trade vehicles will follow routes offering easier gradients or freedom from restraints, as for example bridge loads, and it may be expected that cyclists will tend to avoid steep gradients or congested routes. Other drivers will not be subject to such restrictions and will have available a wider range of choice as to the routes they take.

It is necessary to consider the factors which may influence the choice of routes by car drivers. The relative length of alternative routes is obviously of concern but more important to the drivers of many vehicles will be the journey times likely to be required for the alternative routes. In practice motorists usually avoid the shorter route if this is subject to restrictions on speed or excessive delays. However, journey times can only be determined when a great deal is known about the quality of the road and the amount of traffic it carries. For these long range predictions, journey times are not known and distances must be used instead.

The first assignment of 1980 traffic to Christchurch streets was made upon the layout of 1959

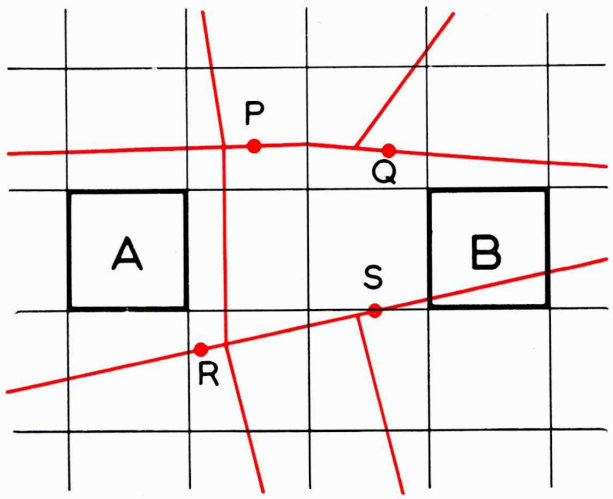


Fig. 62. ASSIGNING TRAFFIC TO ROUTES BETWEEN SUBSECTORS: A DIAGRAMMATIC REPRESENTATION. Subsectors A and B are served by alternative streets (in red): P, Q, R and S are key points on the street system.

streets (Figure 64). To turn travel between subsectors into traffic on the streets, it was necessary to assign traffic to key points on the existing street system. In so doing, the influence of congestion was disregarded. In other words, it was assumed that the capacities of all routes would at all times be equal to the demand and that traffic would be able to take the most direct and convenient route. This was done deliberately as it provides a method of estimating the demand on existing streets and of assessing the extent to which alternative routes could be used by any overload.

There is generally no serious problem in assigning traffic to routes between suburban subsectors. For a pair of subsectors, as shown in Figure 62, it will usually be of sufficient accuracy to make a subjective estimate of the proportion of each subsector which is most conveniently served by a given route and to assign traffic between subsectors in terms of the amount passing through nodal points along that route. There are two reasons for the use of this simple method. First, the number of alternative routes available is usually very limited and, secondly, the traffic from subsector to subsector, for example, from A to B, is likely to be only a small fraction of the traffic upon the routes serving them, for example, upon P, Q, R and S, because many other subsectors will also be contributing to the movements along these roads.

The assignment of traffic within the Central Traffic District of Christchurch is a much more difficult problem. The choice of entry points and subsequent routes is wider; focal points able to generate heavy traffic are more ubiquitous; and the greater part of the traffic terminates within the Central Traffic District. In addition the difficulties of parking often influence a driver's choice of route within the city; in other words, a driver may travel not by the most direct route for his particular purpose, but by the direct route to the place where he hopes to park his car. Properly speaking, assignment within the city centre can only be done after parking areas have been settled. It was realised that it would be very difficult to make an assignment to the streets of the Central Traffic District, and, therefore, no attempt was made to assign 1980 traffic to 1959 streets in this central area.[1] Figure 63 shows the central portion of the Internal Area, the 'Belts',[2] and a number of nodal points through which traffic to the Central Traffic District must pass. The assignment of 1980 traffic to 1959 streets was made with respect both to these nodal points and to the Belts, but was not carried nearer to the city centre (Fig. 64).

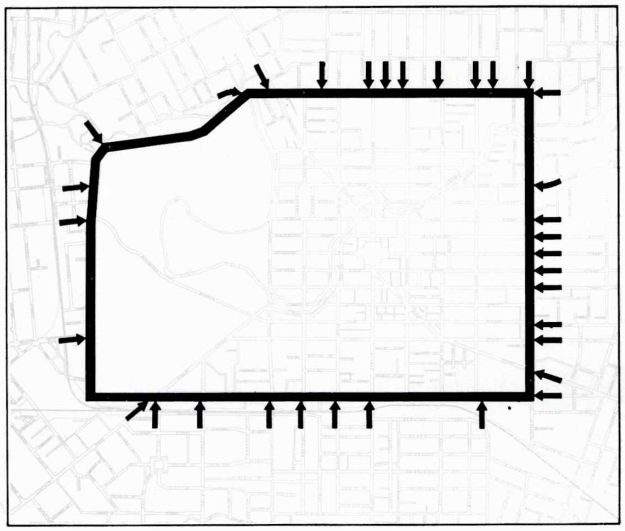


Fig. 63. CHOICE OF ENTRY POINTS ON TO THE BELTS. There is a wide choice of routes and entry points to the inner city from the north, east, and south.

What is required now is some means of evaluating these traffic forecasts in terms of what it will be like, as a driver or pedestrian, to experience such traffic; what proportion of existing roads will be overloaded if called upon to deal with such flows; and what new or improved roads may be needed to carry such traffic. The estimates of future travel in Chapter Five indicate that, by 1980, the number of trips to and

[1] To correct any confusion which might arise from this paragraph, it should be explained that, in the course of developing the Master Transportation Plan, detailed assignments have been made of 1980 traffic to proposed 1980 streets and have been made right into the centre of the city. Such matters are beyond the scope of this publication.

[2] The term 'Belts' refers to Deans, Harper, Bealey, Fitzgerald and Moorhouse Avenues; the Belt Cordon Line lies immediately outside the Belts.

from the Central Traffic District are expected to increase by 107 per cent over those recorded for 1959. A mental picture of traffic conditions resulting from this 107 per cent increase is readily obtained by those familiar with Christchurch. At the present day the off-peak traffic volumes into and out of the Central Traffic District are a little more than half the evening peak hour volumes. If this ratio continues, as is expected, the *off-peak volumes in 1980 will be a little higher than the present-day peak hour volumes.* By the same token, *the overall street system will have to be able to carry at least twice the present peak hour traffic volumes.* It is necessary, however, to evaluate the traffic on individual streets in the system.

STREET CAPACITIES

The evaluation of 1980 traffic in relation to the street system of 1959 requires an assessment of the capacity of existing streets in terms of traffic. To assess the capacity of urban streets is very difficult in many ways and the methods are rather specialised. However, it is the general principles that are relevant to the present discussion.

One of the basic problems involves the mixture of modes of travel. Cycles, with poor qualities of speed, acceleration, braking and stability, are in startling contrast to motor vehicles. Buses and trade vehicles, with a smaller ratio of power to weight, have dynamic properties generally inferior to those of the private car and, unfortunately, the large bulk of such a vehicle creates a visual obstruction. Pedestrians also have considerable access in a traffic system and require careful consideration.

No engineer would intentionally devise a mechanical system to contain such diverse elements upon the same tracks. Equally, no engineer can be expected to calculate the capacity of such a system with the same precision as he would calculate the flow of liquid through a pipe or of electricity through a conductor. Calculations are only possible in respect of numbers which are statistically large. A group of careful motorists may, for example, occupy more road space than a group of more reckless motorists; calculations can only be made in respect of vehicle numbers sufficiently large to eliminate chance variations.

Every road feature which causes a driver to check his speed, drive farther from the kerb and thereby make it more difficult to overtake him, or delay overtaking, will reduce the capacity of a street. In this way road curvature, excessive camber, deep gutters, parked cars, potholes, imperfect surfaces, and many other things will affect the capacity of the urban street.

It may be pointed out, by contrast, that for a rural main road or any motorway the calculations are more exact. Such roads will carry motor traffic predominantly, and this will be subjected to fewer obstructions and surprises. Fast, uniform speeds and reasonably uniform vehicle spacing can be relied upon.

Plate XXIII. '. . . . intersections are bottlenecks . . . .'

Street intersections are two routes (or ways) sharing one common area of road paving. The minimum interval between two vehicles using this common area is probably not greatly affected by the relative movement of the two vehicles: a vehicle following another in the same direction will do so at a time spacing not very different from that of a vehicle crossing the path of another. It follows that the capacity of an urban street system is fixed very largely by the capacity of the intersections and not by the streets themselves. At the intersection of two equally wide streets, for example, the capacity of the common intersecting area is approximately equal to the capacity of either street and is thus only about half of their total.

Plate XXIV

Traffic Today — and Tomorrow?

'. . . . off-peak volumes in 1980 will be higher than present peak volumes . . . .'

'. . . . the mixture of traffic . . . .'

'. . . . a place to walk . . . .'

As remedies for this state of affairs, extra traffic lanes are often provided at intersections and the intersections are controlled by traffic officers or traffic signals. Extra road width may be created to give these additional lanes, or obtained by banning parking or bus stops from the kerbside lane. In either case the remedy is partial only and the intersections remain as the bottlenecks. They restrict the capacity of a street system to much less than the theoretical capacity of the individual streets.

It is impossible to consider traffic capacity except in terms of the standard of service provided. At an intersection it would be rare for a vehicle to be long delayed if the traffic is light. As the traffic becomes heavier however, a driver will wait longer for a gap to occur in the opposing traffic stream. Ultimately, as the capacity of the intersection is approached, the wait for a suitable gap will become excessively long.

American highway engineers[3] define 'basic', 'possible' and 'practical' capacities of highways and intersections, and these may be simplified for our use here. Basic capacity is theoretical and applies to all straight level roads of the same width; possible capacity takes account of the imperfections which reduce the capacity of a particular road; practical capacity also applies to a particular road, and to particular locations only, and it makes the further reductions necessary to ensure that a satisfactory service is provided.

Practical capacity is indeed an individual matter to be calculated separately for every road and for many parts of those roads, in the light of local highway and traffic characteristics. For the purpose of studying the Christchurch street system, as an entity, it was necessary to generalise as to street capacities and to adopt average values. These were practical, in a sense, and were considered reliable for an accurate assessment of a street system. The values adopted would not, however, meet the above definition of practical capacity nor can they be relied upon in relation to a particular street; they are described as 'design capacity' for the purpose of this account.

The design capacity is based on the criteria shown in Table 30. These have been developed from a consideration of published data and investigations of Christchurch roads. Particular notice was taken of recent traffic counts made upon Riccarton Road and Papanui Road. These suggested that, under prevailing conditions, some sort of ceiling had been reached for these streets at about 12,500 motor vehicles per day, the total for movements in both directions. The critical matter in design capacity is peak rates of flow but daily totals were more useful for the present study. Therefore, the evening peak hour traffic was taken as 10 per cent of the daily total and was assumed to be divided 60 per cent to 40 per cent in favour of the 'homeward' or 'out-of-town' direction. The peak hour capacity, so determined, was considered to be realistic.

The design capacities for streets, as finally determined, are equivalent to about 75 per cent of possible capacity (as defined above); the design capacities for intersections are about 90 per cent of possible capacity. The design capacities are believed to offer a standard of service similar to

TABLE 30

DESIGN CAPACITIES ASSUMED FOR THE CHRISTCHURCH STREET SYSTEM*

Details of Street	*Design Capacity in Motor Vehicles per 24 hour day*
Street with 46 ft. carriageways (i.e. approx. 4 lanes) ..	15,000
Street of 6 traffic lanes	25,000
Street of 8 traffic lanes	40,000
Intersection of 2 carriageways each 46 ft. width) without special provisions such as widening to provide extra approach lanes	19,000†

* The figures in the table are based on the following assumptions:
(a) that parking and stopping in kerbside lanes are prohibited in the peak hour in order to leave a lane for use of bicycles, stopping buses and left turning vehicles, and
(b) that, because of cycles, buses, etc., the kerbside lanes are largely ignored in arriving at these figures:
(c) that the evening peak hour traffic is 10 per cent of total traffic for 24 hours and is distributed 60 per cent to 40 per cent in favour of the 'homeward' direction.

† Sum of the two streets represented by the intersection.

[3] *Highway Capacity Manual*, published by Highway Research Board, U.S. Dept. of Commerce, Bureau of Public Roads, Washington D.C., 1950, Part I.

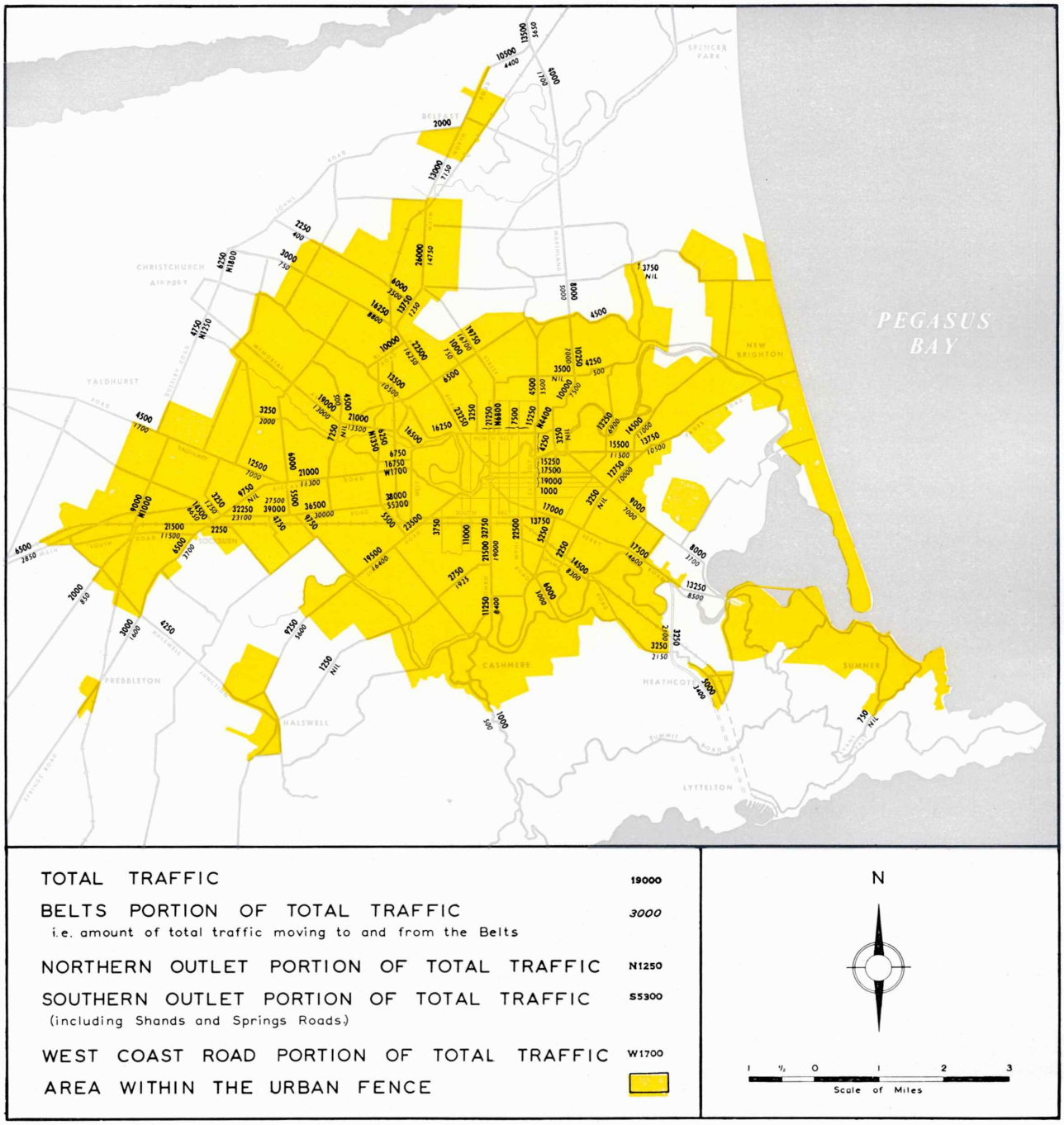


Fig. 64. 1980 TRAFFIC: ASSIGNMENT TO THE STREETS OF 1959. The influence of congestion is disregarded and it is assumed that traffic will be able to take the most direct and convenient route. Traffic covers private cars, taxis and trade vehicles in 24 hours on an average weekday. Buses and all types of cycles are excluded. Urban fence is as defined in 1959 and is assumed to contain the 1980 population of the Internal Area. Traffic volumes just outside the Belts include not only vehicles going into, out of, and right through the centre, but also those that will have to travel along the Belts to get to and from other parts of the city.

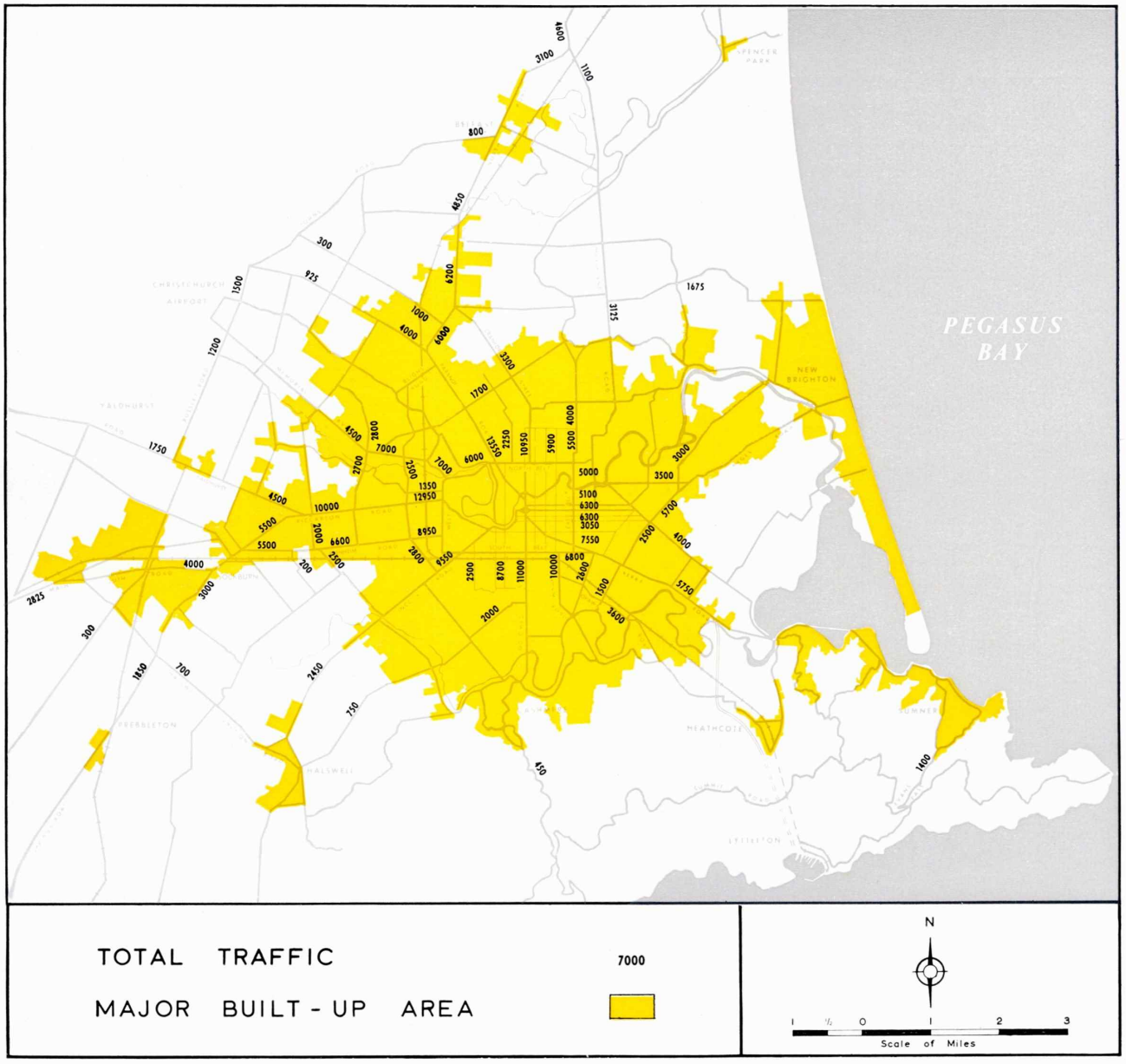


Fig. 65. 1959 TRAFFIC: MACHINE COUNTS ON THE STREETS. Traffic covers private cars, taxis and trade vehicles in 24 hours on an average weekday. Buses and all types of cycles are excluded. Traffic volumes just outside the Belts include not only vehicles going into, out of, and right through the centre, but also those that will have to travel along the Belts to get to and from other parts of the city.

that at present found on those parts of the Christchurch system that are subject to dense traffic. If conditions similar to the worst occurring today extended over large parts of the street system, it is unlikely that they would be acceptable to the community. Such a situation will appear in the future as the city grows and extends, unless remedial measures are taken.

1980 SITUATION

A comparative study of 1959 and 1980 traffic, by streets, illustrates the scale of the effects. Figure 64 shows 1980 traffic assigned to 1959 streets and the key explains the two sets of figures. At any location the numerically larger figure is of total traffic, and its numerically smaller companion is of traffic proceeding to or from the Belts. Smaller

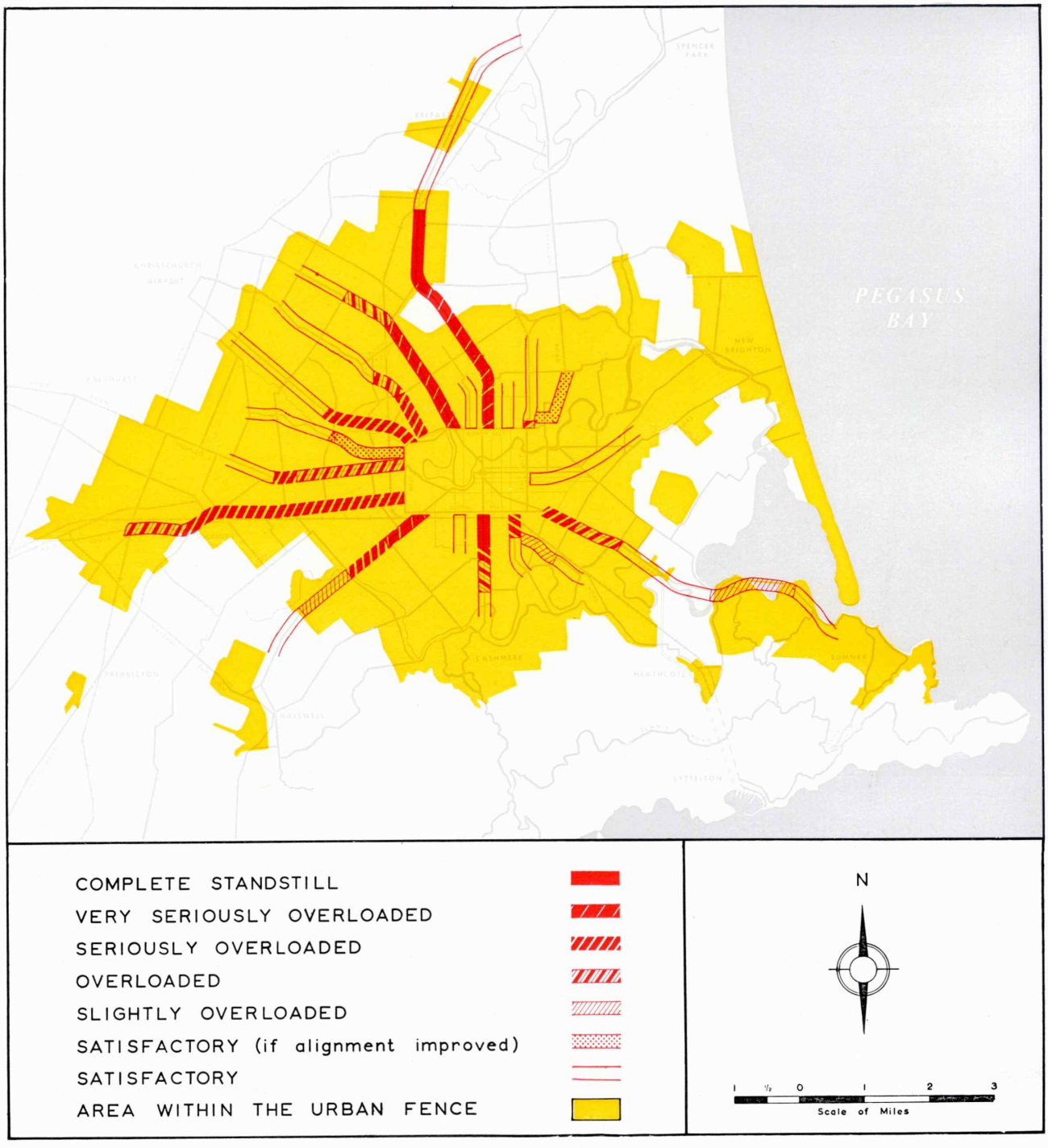


Fig. 66. 1980 TRAFFIC: SITUATION ON THE RADIALS OF 1959. The traffic of 1980 is assigned to 1959 streets by disregarding the influence of congestion and assuming that traffic will be able to take the most direct and convenient route. The situation is therefore the extent of overloading if the radials of 1959 were required to carry 1980 traffic. Allowance is made in the 1980 traffic for differences in the areal rates of growth relative to the urban fence which is as defined in 1959. See Table 56 in Appendix H for further details.

separate figures at the Belts indicate the portion of traffic with origins and destinations in the External Area and which would proceed via a northern or southern outlet, or by the main road west. The figures given are of motor vehicles (private cars, taxis and trade vehicles) for a 24 hour Wednesday in September or October, 1980, and are therefore directly comparable with those of Figure 65 which shows 1959 traffic. The data of this latter diagram was obtained by machine counting.

For the purposes of forecasting 1980 traffic it was generally assumed that the Internal Area would contain the 1980 population. But, as has already been shown in Chapter Four and especially Figure 49, the relative rates of growth from one urban sector to another will vary and some of the available areas within the urban fence will be filled in at different times from that of the design year. Therefore in assessing 1980 traffic upon the roads of any one sector of the city, the differential rates of urban development from one sector to another must be considered, as indeed must the potential for urban development beyond the urban fence. Detailed evaluation of the situations on the main radial routes and on the Belts is made in Appendix H (Table 56): Figures 66 and 67 show the extent to which the radials and Belts would be overloaded if they were really required to carry the 1980 traffic. These diagrams illustrate the general nature of the problems but do not necessarily imply that all overloaded roads must be replaced or upgraded in order to solve the problem. Some roads must perhaps be treated in that way; for others it will suffice to divert some traffic from them.

PROBLEMS REVEALED

The problems created by the traffic increases will chiefly concern radial routes and the central area of the city. The radials are especially involved as trouble spots, for not only will at least ten radials require relief, but some dozen intersections of radials with intersuburban roads will become seriously overloaded. This will arise because the radials will be carrying the heavy volume of traffic making for the Central Traffic District and, in addition, much of the other traffic will be using or crossing those same radials. As the radials approach the Belts, practically all but those in the northeast will be overloaded to some extent. The worst will be Papanui Road, the Cranford Street route, Colombo Street (South) and Lincoln Road, all of which are expected to be very heavily overloaded.

The traffic desiring to stop or park in the Central Traffic District, an area which is small, already busy and where land is expensive, will be more than doubled by 1980. There are the obvious problems of providing suitable terminal facilities—car parks, bus stations, unloading points for trade vehicles—and, in addition, convenient access must be provided to these. The Belts therefore arouse concern, for they are the first means of distributing the traffic destined for the city centre along any of the radials. But, in turn, problems will also arise within the Belts in regard to the redistribution of traffic, once having passed through the Belts.

The 1980 traffic situation on the Belts (Fig. 67) presumes that the assigned traffic will reach the Belts by the 1959 routes and at the 1959 intersections and this, of course, is not possible. Many of the radials must, before 1980, be improved or relieved by new bypass routes and the Belts will also be overloaded and require to be bypassed, improved or bridged. The points where existing radials meet the existing Belts may be thought of as the existing inlets to the city centre. Since the improved radials and other relieving measures of the future must tap the same catchment areas as at present, they must have similar points of entry within the Belts. Artificial or otherwise, this assignment of 1980 traffic to the 1959 Belts does aid in an appreciation of the problems that will exist.

A detailed assignment of traffic to individual streets within the Belts has not been made but it is known that the forecast traffic in 1980 to and from the Central Traffic District is double that in 1959. This suggests a possible similar increase on central city streets. However, by careful location of parking and other terminal facilities, relative to access routes, some of the potential increase need

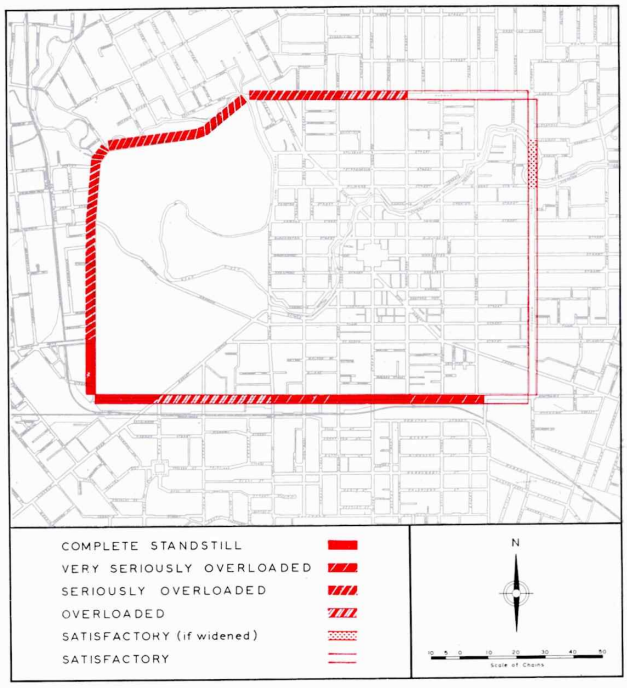


Fig. 67. 1980 TRAFFIC: SITUATION ON THE BELTS OF 1959. The traffic of 1980 is assigned to 1959 streets by disregarding the influence of congestion and assuming that traffic will be able to take the most direct and convenient route. The situation is therefore the extent of overloading if the Belts of 1959 were required to carry 1980 traffic. Allowance is made in 1980 traffic for differences in the areal rates of growth relative to the urban fence which is as defined in 1959. See Table 56 in Appendix H for further details.

not reach the heart of the business district.[4]

To meet the situation, the Central Traffic District has a reserve. Some of the streets are not used to capacity, and restrictions on parking and stopping, and the introduction of one-way systems would improve their efficiency. However, the improved efficiency, though very valuable as an interim measure, will not increase sufficiently the capacity of the street system to carry the very large increase in traffic which is expected by 1980. Furthermore, in the long term it may be considered that the relatively minor benefits to be gained by restricting parking and stopping, may not compensate fully for losses in convenience for those using the centre for business and requiring short period parking. It is therefore very doubtful if the Central Traffic District can accommodate the expected increase in traffic, except by a more radical approach. The increasing installation of traffic signals, which has gained momentum in recent years, is in itself an indication of mounting difficulties and the need for a new approach.

Besides the radials, Belts, and central city streets, there is one other important group—the intersuburban routes. The traffic volumes anticipated on these roads in twenty years' time can be seen on Figure 64.

Today there are many similar routes of varying degrees of importance and it is to be expected that the relative significance of each will change with time. Because there is a limit to urban development in the inner suburbs, the traffic on some inner connecting routes may well build up, by 1980, to volumes beyond which little increase is likely to take place. However, those towards the outskirts of the city, including bypass routes, will not generally reach their limit in these terms but their importance for certain kinds of traffic is no less. Especially important is the Russley Road route which provides a bypass for the limited amount of north-south traffic and is also the main access, from north and south, to the Christchurch International Airport. It therefore needs careful consideration, as ultimately it may be absorbed into the built-up area. If this occurs its usefulness as a bypass and airport route would be seriously impaired unless consideration is given to protecting it as a high class highway.

PARKING AND 1980

The discussion of 1980 traffic has so far been based upon certain important assumptions: first, that the number of motor vehicles, owned and used, will continue to increase in absolute totals and in relation to the growth of population; second, that the outward growth of the suburban areas will, by extending the distances to be travelled, increase the attractiveness of motor vehicles as a means of travel to the Central Traffic District; and third, that there will be no frustra-

[4] In the course of developing the Master Transportation Plan, detailed assignments have been made of 1980 traffic to proposed 1980 streets and they have been made right into the centre of the city with due allowance for parking.

tion on city streets to thwart a driver's desire to use his vehicle. On these assumptions, the traffic to the Central Traffic District is expected to more than double by 1980. Obviously if frustration is to be avoided a vast additional amount of car parking facilities must be provided within convenient reach of central destinations.

In 1959 there were some 5,500 spaces for on-street parking and 5,000 spaces for off-street parking within the Central Traffic District. The latter includes many places in private alleys, yards and forecourts. Traffic and the need for parking places builds up steadily after 7 a.m. to a high density by 9.30 a.m.; the parking demand remains high until 4.30 p.m.; by 6 p.m. the central area of the city is almost clear (Fig. 68); demand rises sharply again in the evening, and on Friday evenings, with late night shopping, the demand for short-term parking in the central business district is excessive. Evening parking demands do not, however, spread out as far from the centre as those for weekdays.

The 1959 parking survey of the Central Traffic District showed that between 9.30 a.m. and 4.30 p.m. on a midweek day the average utilisation of parking spaces within the Central Traffic District as a whole was approximately 75 per cent for on-street and 60 per cent for off-street. An additional four per cent of on-street spaces was occupied by vehicles that were informally parked, for example, on 'No-Parking' areas and bus stops, or were double parked. The Central Traffic District is, however, too broad an area within which to consider parking associated with the commercial area of the city centre. As was shown in Chapter Three (Fig. 28), the greatest demand for available parking space occurs in the area bounded by Hereford Street, Oxford Terrace, Lichfield Street and Manchester Street. Here the average utilisation of on-street parking reached over 90 per cent (plus 11 per cent informal) and appeared to be completely saturated in 1959.

Within the Central Traffic District on-street parking was heavily utilised but the pressure for off-street parking was not so great although reaching 75 per cent in some parts. The figures for the District as a whole might be considered as not very serious at first sight but it must be remembered that the Central Traffic District includes relatively remote on-street parking as well as a large part of the central business district and that, therefore, some motorists have lengthy distances to walk after parking their cars. Furthermore, saturation point is normally regarded as 85 per cent utilisation of parking space and therefore, even allowing for the whole of the Central Traffic District, the pressure is considerable.

The number of 'customers' going to businesses such as banks, offices and shops in the Central Traffic District is very variable. Frequently customers arrive to find a queue already waiting and yet at other times the same shop or office may be nearly empty. In the mathematical sense the demand for services of this kind is a random one, and varies widely over the day. City car parks are needed by persons doing business in these same shops and offices and it follows that this demand does not occur in all areas at a constant rate throughout the day. The chance arrival of customers and their vehicles always results in some shops, offices, and parking facilities being under temporary and excessive pressure. These chance variations of demand are associated with nearly all human activities and are dealt with by providing some reserve of capacity, in the same way that the telephone services provide more telephones and lines than are required for the average number of calls.

If a reserve of capacity is not provided, waiting and queueing must occur at moments of peak demand, and motorists requiring car parks must cruise around until they find what they need or, becoming frustrated, go further afield for their parking or business needs. Drivers concentrating on the search for parking spaces are a danger and a nuisance to other road users. They are also wasting the valuable time they have gained from the use of private transport, and thus lose part of the advantage such transport affords them. If the aim is to provide central car parking for all, it must be on an adequate scale. To provide for an overall utilisation of only 85 per cent of the spaces, allows for the time necessarily occupied in entering or leaving a parking space. It also makes some provision for variability of demand; in no sense is it an extravagant provision.

V. C. Browne Airview

Plate XXV. Parking in central christchurch, 1964.

TRIP PURPOSE

The analysis of the 1959 surveys related parking demand to trip purposes, that is, whether trips were made to the central area for employment, shopping, business, and the like (Fig. 68). The traffic forecasts for 1980 have been made in terms of the same variables, and it has thus been possible to make forecasts of the future parking needs. It is estimated that, by 1980, more than 20,000 vehicle spaces will be required of which eight per cent (about 1,600 places) will be needed for trade vehicles.

There must inevitably be some loss of present on-street parking spaces, for the growth of bus and taxi services will bring a need for extra bus stops and taxi stands. Kerb space for parking will also be lost by the provision of additional property entrances, for traffic signals, and if restrictions on parking should be needed to promote traffic flow. In addition there will be some loss of present off-street parking spaces because of building developments and increasing use of yards, private alleys and forecourts for off-street loading operations. On the other hand, there could be an increase in available space, though at greater distances from desired destinations, if all-day parkers were compelled to go further afield because of an extension of the metered areas. But this will produce, as it does today, conditions which are bad and undesirable for adjoining property owners. Since the present maximum walking distances are about a half mile, it is doubtful if any relief should be expected from this source.

The net result of these changes has been estimated as an increase, by 1980, of more than 10,000 spaces, all of which must be provided off the streets. To meet this need by 1980 would require the provision of off-street parking at the rate of 500 each year for the two decades between the survey year of 1959 and the design year of 1980.

It is important to consider the purposes for which motorists will be in the Central Traffic District and, hence, the likely duration of their parking needs. Based upon the number of persons making trips to work, business or shopping, the requirements for 1980 are estimated in Table 31.

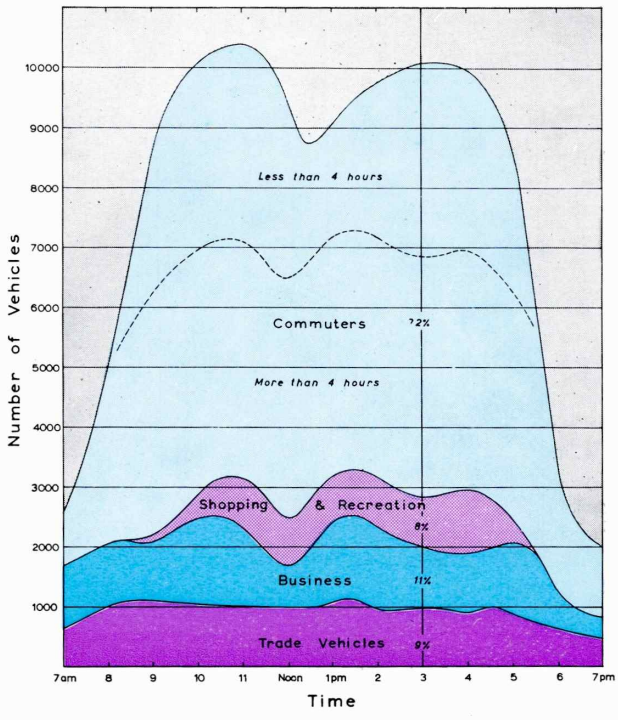


Fig. 68. PARKING IN THE CENTRAL TRAFFIC DISTRICT, 1959: BY PURPOSE AND TIME.

TABLE 31

PERCENTAGE OF PARKING SPACES REQUIRED IN THE CENTRAL TRAFFIC DISTRICT, BY PURPOSE : 1980

Purpose	*Mean Parking time*	*Percentage of Total Parking Spaces*
To Work only ..	8½ hrs.	47%
To Work with later trips ..	3 hrs.	28%
To Work and use of car on business	1 hr.	10%
Shopping and recreation ..	1 hr.	7%
Trade vehicles ..	1 hr.	8%

It is necessary to note that this measurement is in terms of 'parking spaces'. A solution to the parking problem must revolve around supplying

adequate long-term parking for the commuter, short-term parking for shoppers and the like, and spaces for trade vehicles and buses. Short-term parkers may be more numerous than long-term parkers but, since the former park for short periods only, they will require proportionally fewer parking spaces because their demands are not simultaneous.

The alternative to providing car parks for all who require them is to encourage the use of public transport. It is relevant, therefore, to look at the different groups of motorists, as in Table 31, and to consider how each would react to changes in public policies on parking and public transportation.

Motorists travelling to work and subsequently using their cars on business during the day appear to be the group for whom cars are most necessary and thus to be deserving of priority in the matter of allocating parking space. They are the group whose working efficiency is dependent upon having cars always available and who would therefore be more likely to use their cars even though parking costs were to rise considerably.

Short-term parkers who travel to shop or for private business will include some who could do their business elsewhere and who may do so if prevented or discouraged from using their cars in the city centre. They form a group which city business people will not wish to discourage or hinder but this idea needs further comment.

It is not to be expected that either all existing customers or all potential customers will do their shopping and business within the confines of the Central Traffic District. The urban area is subject to continuous change in response to various pressures, one of which is the relative accessibility of the various parts of the city. The expansion of the urban sphere of influence and the growth of population are accompanied by an increase of all kinds of productive activities. Many of these activities are done most efficiently at the city centre and the demand for land creates the keen competition for locations in the central business area. Those land users who can carry out their business as effectively elsewhere are likely to give way to those for whom a central location is particularly necessary or attractive. A number of American cities report a tendency, over the last decade or more, for banks, insurance companies, specialised business and retailing to maintain their places at the centre. The more general retail traders, on the other hand, are pressed by competition, both for central sites from other users and for trade from suburban competitors, to move to suburban centres. These changes in the internal structure of cities are very much the product of city growth and development.

The significance of this to the parking problem lies in the rate at which changes occur. The rapid development of a shortage in central parking would precipitate the decline of central retailing to an extent both harmful and undesirable for the whole community.

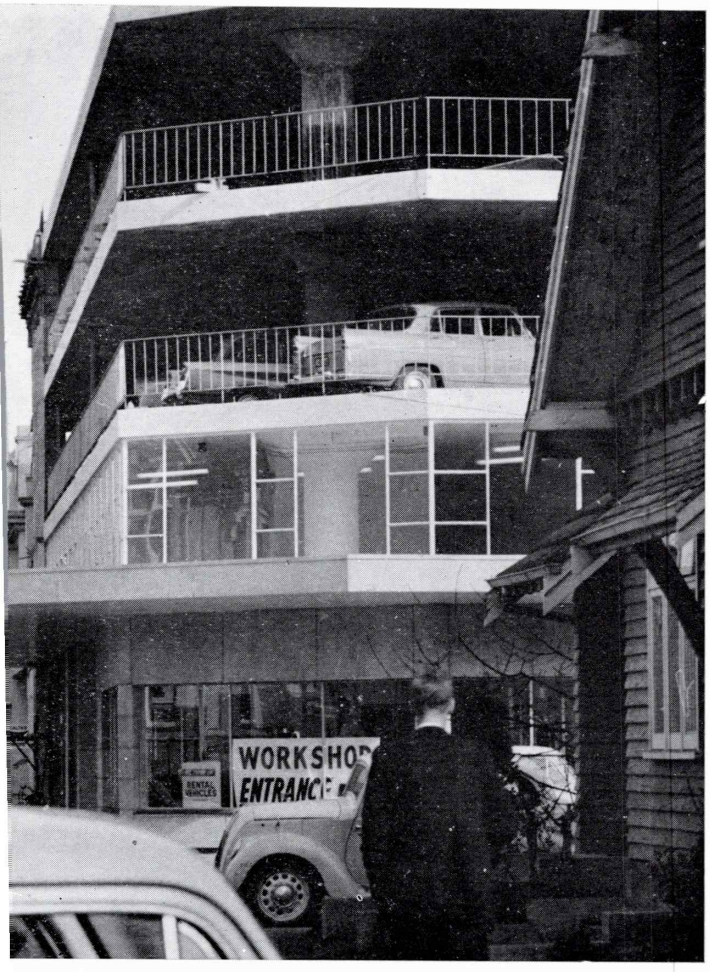
Motorists who travel to work and do not subsequently use their cars form the group which can be most conveniently diverted to other means of transport. Indeed, a strong case could be made for a policy of encouraging such persons to travel to work by bus or train. This type of motorist may use more ground space for the parking of his car than he occupies in his office or work room. Moreover, he travels at the same time each morning and evening, and it is he in particular who creates the peak traffic which may soon necessitate expensive new road works. Against this, however, must be set the fact that a diversion of this group to mass transportation would greatly increase the peaks of morning and evening passenger traffic, without a corresponding increase in off-peak traffic; the net result would be increases in the cost of running passenger services. Another factor is that the provision of parking for commuters is generally cheaper than for others because the former can be accommodated further out than the short-term parker who demands space in the heart of the business area. The worker-motorist is, moreover, a consumer as well as a producer, and part of the attractiveness of travelling to work by car is the facility it provides to do other errands en route.

The analysis of 1959 traffic data suggested that the worker-motorist may also be a significant customer within the area in which he works; this appeared to be the case for Sydenham, and

Plate XXVI

Parking Today— and Tomorrow?

'. . . . the short-term parker and business . . . .'



'. . . . demand for off-street parking . . . .'

'. . . . parking the two-wheeler . . . .'

TABLE 32

LAND AREAS REQUIRED FOR OFF-STREET PARKING: 1980

	METHOD	*Area Required*	*Equivalent Number of City Blocks (each 11 chains × 5 chains)*	*Equivalent Proportion of C.B.D.* land area excluding streets (136 Acres)*	*Equivalent Proportion of C.T.D.† land area excluding streets (337 Acres)*
I	All surface parking ..	106 Acres	19.50	0.79	0.32
II	All in 5 storey parking buildings	21 Acres	3.85	0.16	0.06
III	Ten buildings each for 500 cars and 10,500 cars by surface parking ..	79 Acres	14.40	0.58	0.24

* The central business district (C.B.D.) in this context refers only to that part lying within the Central Traffic District (see Figure 70 in Appendix B). The parking areas need not be within it provided they are within convenient walking distance.
† Central Traffic District.

perhaps also for Riccarton and Addington. The amount of travel generated in these areas was low in relation to the amount of shopping activity but this was explicable if local workers were presumed to be good customers of local shops.

The worker-motorist also uses his car in order to reduce the time he spends in travelling. This saving increases either his working time and productivity or his leisure time and standard of living. The final assessment of the worker-motorist as opposed to travel by mass transportation resolves itself into a financial matter—the level of cost at which an individual is willing to change his mode of transport, a level which is not to be thought of solely in terms of direct, comparative costs.

A 'motor-car city' permitting easy access at all times to all parts will be expensive to create and the costs must be borne directly or indirectly by all users and residents of the city. Against these costs must be set the savings in time—in terms of leisure and production—as well as the convenience offered. These also have a monetary value although not always so easily measured as the savings in transportation costs of vehicle running and maintenance.

LAND REQUIRED

Motor cars at rest are extravagant users of land and it is necessary to consider how much of the central area will be required for future parking. Some 5,000 off-street places are already available and a total of more than 15,500 will be needed in 1980. In Table 32 estimates are made upon the assumptions that each of the 15,500 cars will require 300 square feet and that where parking buildings are provided, these will be of five parking storeys and reached by approach ramps. The third of the alternatives in Table 32 is interesting as it shows that an area equal to about one-quarter of the Central Traffic District (excluding streets) would be occupied with car parks. In terms of the large part of the central business district that lies within the Central Traffic District, over one-half of the present area (excluding streets) would be in car parks.

The extent to which motor transport now dominates and will continue to dominate our cities is quite astounding when it is remembered that, in addition to car parks, a substantial portion of the central area will be occupied with roads, bus stops, taxi stands, private alleys and loading bays. Yet these predictions for Christchurch of

1980 are not unusual; indeed, they appear to have similarities to American cities of comparable size and density. In comparable American cities with a central business district averaging 0.54 square miles (340 acres), some 12 per cent (41 acres) is used for off-street parking and 30 per cent (100 acres) is occupied by streets of which one sixth (16 acres) is used for on-street parking. The total area used for streets and parking is 42 per cent of the central business area.[5]

Another way of looking at the Christchurch parking problem is to consider it in terms of floor space required and compare this with the floor space required for other purposes. It is estimated that by 1980 there will be a 40 per cent increase in employment in the Central Traffic District. Assuming a corresponding increase in the floor space of the business area that lies within the Central Traffic District, then by 1980 there would be 11½ million square feet of floor space used for normal central business purposes. The ratio of 1980 central business floor space to off-street parking floor space within the Central Traffic District would be about 5 : 2. A substantial proportion of the business area will not be available for either off-street parking or for business buildings; it will be occupied by streets, open spaces, or low-level community buildings such as churches, theatres, and other places of public assembly. It is apparent, therefore, that unless the business area is to spread outwards and invade more of the Central Traffic District, it will certainly have to spread upwards with the construction of high level buildings.[6]

PARK AND RIDE

A 'park and ride' system has often been suggested as a means of alleviating the traffic problems of Christchurch. In such a system large car parks are provided beyond the busy centre of a city, and travellers leave their cars in a park and complete their journeys by train, bus or taxi.

This method is not considered suitable for Christchurch. If used at all it would be in conjunction with bus services, rather than train services, but there are local difficulties. The journeys made to the Central Traffic District are usually comparatively short, of two or three miles, and yet many persons undertake them by car on account of the saving in time and convenience. It would be difficult, in the case of these short journeys, to provide a dual system that showed any worthwhile saving of time and convenience, compared with travelling by bus all the way.

The transfer points would have to handle sufficient traffic to make the bus services no more uneconomic than they are at present, and yet the larger the stations the further some users will have to walk after parking their vehicles. However efficient the transfer arrangements may be several minutes would inevitably be required for the change of vehicle.

The wide and regular growth of Christchurch around its centre creates a difficulty because a small number of transfer stations will not suffice. In some urban areas of similar population size the physical constriction of site provides a natural point for transfer between car and public transport. This is the case, within New Zealand for example, between Hutt and Wellington cities.

For Christchurch, the park and ride system does not seem financially attractive for the motorist because he would tend to pay twice over for his journey; his motoring cost and his bus transport cost might each be equivalent to the cost of using only one mode for the whole journey.

PUBLIC TRANSPORT

The alternative to the provision of adequate and convenient parking for the Central Traffic District is to provide adequate public transport which is sufficiently cheap and convenient to attract travellers to use it in large numbers in preference to their own private transport. There is, nevertheless, little evidence in New Zealand or in overseas towns the size and character of Christchurch, to suggest that the movement of people by mass transportation will increase significantly. From trends over the last 20 years (Table 33), it is

[5] *Parking Guide for Cities*, published by U.S. Department of Commerce, Bureau of Public Roads, Washington, 1956, p. 19.

[6] For some discussion of possible costs of providing parking facilities see Appendix F.

Plate XXVII

Problems of Public Transport

'. . . . numerous level crossings and the flat site . .'

'. . . . no natural focus for a suburban rail network . . . .'

'. . . . low population densities and wide dispersal around the centre . . . .'

expected that in Christchurch in the next 20 years, public passenger transport will not be able to make any major additional contribution to the transport scene and, relatively, may lose ground. There is no special characteristic of the urban area of Christchurch upon which to base any divergence from an almost universal trend in 'western' cities of comparable size. Rather, the likely nature of Christchurch's urban growth in the future seems to favour the common pattern.

TABLE 33

GROWTH OF POPULATION, REGISTERED VEHICLES, BUS PASSENGERS, AND BICYCLES FOR CHRISTCHURCH: 1939-1959

	1939	1959
Population* ..	142,000	217,330
Motor Vehicle Registrations* ..	25,533	66,723
Bus Passengers** ..	20,000,000	21,000,000
Bicycles	90,000†	90,000††

* Table 49 in Appendix H.
** Christchurch Transport Board.
† Estimated on information from cycle trade issue of rear light reflectors.
†† Assessed from 1959 travel surveys.

It is for these, and other reasons discussed in Chapters Four and Five, that an increase of only eight per cent in bus use is forecast for 1980, although the population will increase by over 50 per cent in the same period. The remaining increase of travel is expected to be by way of private cars and it is this striking trend which is expected to create the parking demand in the Central Traffic District. In many ways greater use of public transport is desirable but this cannot be relied upon in the future to any significant extent.

CONCLUSION

In this chapter the problem of distributing 1980 traffic among the streets of Christchurch of 1959 has been studied. The increase of traffic will give rise to specific problems of congestion along radial routes and in and about the city centre, unless remedial measures are undertaken. Most of these problems will arise first at major intersections.

The doubling of traffic in the Central Traffic District will create an obvious and critical problem in terms of parking facilities which must be provided, if the central area is to develop its essential character as the economic and cultural focus for the city's activities. If the heart of the city is strangled by traffic congestion on its streets as well as along the access routes to it, the whole structure of the urban area and its circulatory system will be drastically altered: the cost to the community is almost beyond calculation.

The comparison of 1980 traffic and existing street capacities indicates the order of magnitude of the planning and building programmes which will be required to keep the circulatory system of the city functioning smoothly. The provision of convenient bus services in expanding suburban areas will be difficult because of the low density of customers. The individual and collective desire for frequent and widespread use of the private motor car will be met only by new highway facilities on a substantial scale.

These travel demands of the none-too-distant future are a measure of the prosperity and wealth of a modern city, which functions best when ease of movement permits specialisation within its various parts to the profit of all. If the city is to grow and prosper, and if the people who live in it are to be busy and productive, there is only one rational choice—substantial community resources must be channelled into the formulation and execution of a transportation plan that will meet the growing demands.

CHAPTER SEVEN

Problems and Prospect

In 1843 John and William Deans established their farm at Riccarton and six years later an area near their homestead was selected as the site of Christchurch, the planned capital for the Canterbury settlement. In December 1850 the first four shiploads of settlers arrived in Lyttelton harbour.

Many were the problems that the founders of Christchurch had to face and it is encouraging to recall the ways in which they solved them. The prospects were for a long, arduous and expensive struggle, for the settlement was sited as much upon swamp as upon dry plain. The pioneer citizens required a full portion of faith in the future to support them in their tasks. They showed vision and forethought in creating some of the formal advantages of contemporary Christchurch; they also made mistakes and misjudgements along the way. But the city grew and prospered as each problem was overcome.

Now some 100 years later, a new plan is being designed, not to found a city but to permit the continuation, indeed expansion, of a hundred years of growth. The need arises from the success of the city itself, a hinterland made productive, a population with high living standards, and a common belief in a prosperous future. It is, however, salutary to pause and look back over the past hundred years and to see that the present step is but one of many in the advancement of the city. The scale of the present problem is formidable—perhaps almost overwhelming at first sight—but it is no greater than the question of simple existence which was faced and overcome in the first two decades of Christchurch's history.

Today, the citizens of Christchurch must face the rapid development of traffic congestion within their city and, if the city is to flourish, they must expedite a solution. Within less than one generation over 130,000 persons are expected to be added to the population now living within ten miles of Cathedral Square, the centre of the city. The growth of 60 per cent in population will require the provision of homes, schools, work places, public and recreational facilities over an enlarged urban area. The particular problem is the increased movement of people and vehicles as they go about their daily tasks of meeting the demands of urban life. This movement is essential to the well-being of the city; it is the basis of specialisation of activities; it is a prerequisite of efficiency; it permits greater productivity per man and greater material benefits and rewards. Ease and rapidity of movement are crucial to a modern city. The provision of a transportation system that encourages and facilitates this movement will make the solution of other problems of growth very much easier.

To discuss this transportation problem requires an understanding of the nature of its causes. A survey of the movements of people and vehicles is a large and expensive task. Because it is important to know why people travel, how many travel, by what modes, along which routes, and at what time, it is necessary to count traffic and to conduct interviews on a large scale. The mass of data that is collected can only be satisfactorily handled through the use of modern data processing machines. In this way the time factor is reduced to a reasonable period and the orderly arrangement of the data leads to a better understanding of the nature of the problem.

For planning purposes the pattern of travel is conveniently considered in terms of the sum of movements on an average weekday. Careful allowance must however be made in any plan for aspects of travel which differ significantly from the pattern on an average weekday: two of the most important are Friday evenings with heavy

traffic associated with late night shopping, and Sunday flows. Travel is seen to have a regularity that reflects the purposes of movement and the means used to overcome the distance involved in the pursuit of these purposes.

The decision to travel involves an assessment, in both economic and social values, of the costs of making journeys and the rewards to be obtained from having made them. The balancing of costs of travel against the rewards obtained from travel gives an equilibrium which is reflected in the travel pattern and this balance or equilibrium is attained against the mosaic of land uses. Land uses are products of the urban activities many of which are arranged, very largely, in a way that reduces the need to travel. However, some activities—for example, an airport with its special site conditions—must give greater weight to other locational requirements, but none can neglect the effect of distance. In many ways, then, urban land use and the related activities are distributed through an urban area in an attempt to shorten the distance that must be travelled by those who use them. In turn, the arrangement of urban activities is fundamental in producing the particular patterns of travel.

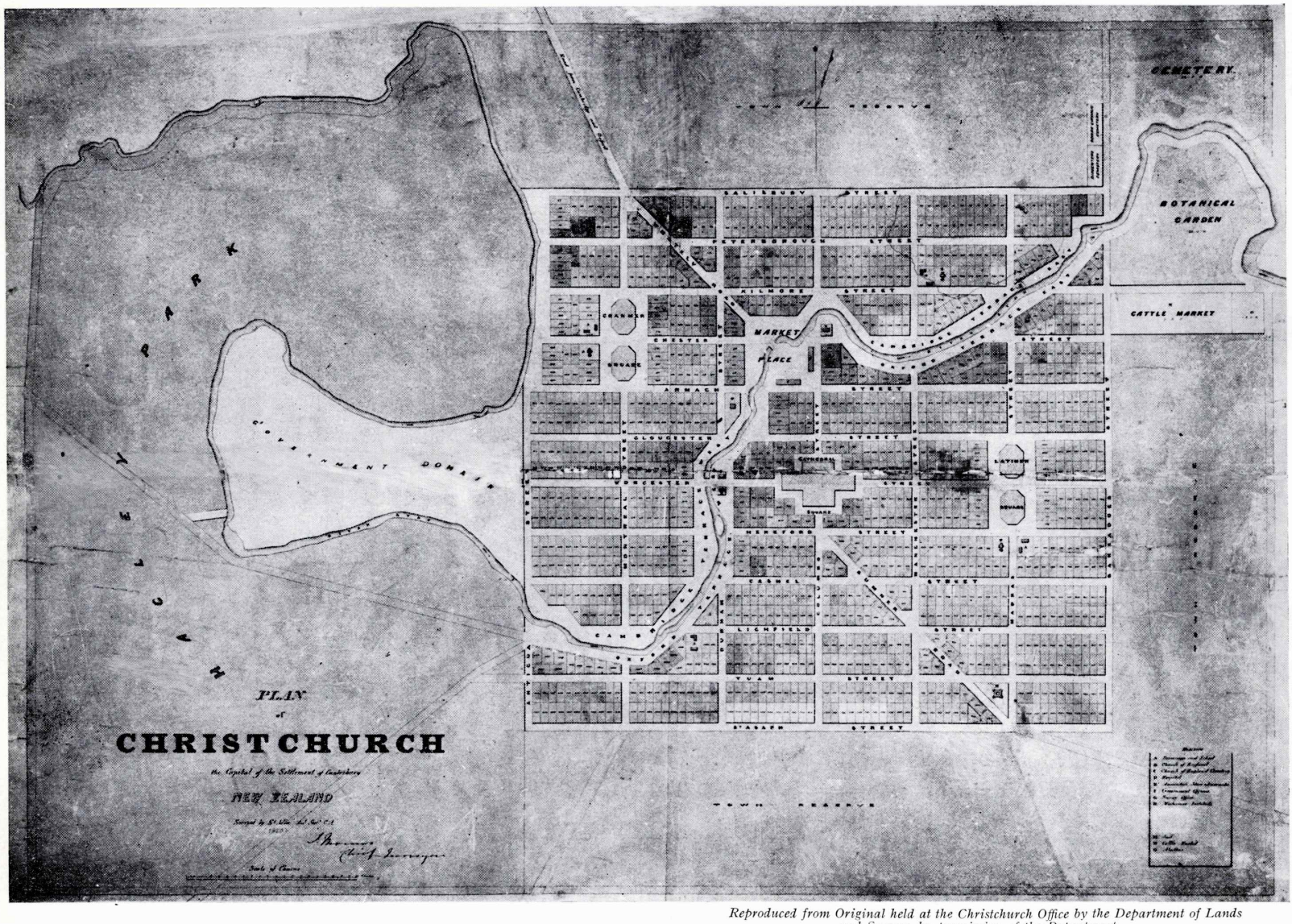
The estimation of future traffic requires a forecast of the size and distribution of urban activities. To make this forecast for Christchurch of 1980, assumptions must be made of the modes of travel that will be in use, the availability of services and the balanced needs of an urban population. The prime mover for change is the anticipated growth of 60 per cent in population. It is expected that the people will have a higher standard of living than that of today and one of the important consequences will be the ownership of more cars per family and an increasing utilisation of them. The number of cars and trade vehicles in 1980 is estimated to increase by over 130 per cent.

The important features of Christchurch in 1980 that will greatly influence travel have been described in turn. The growth of population will require an extension of the living area, and will produce changes in the mode and distance of travel. More people will seek employment and, in so doing, will generate travel which is particularly significant for industrial and commercial areas. The improved levels of living of the people will, it is assumed, be distributed over the city in a pattern similar to that at present and as indicated by the valuation of residential property.

One outcome of the changing face of the urban area is a doubling of traffic in the central part of the city; in 1980 off-peak traffic will have volumes like those now occurring in peak hours. For all the Internal Area the overall growth in vehicle trips is expected to be over 140 per cent. The estimates of 1980 travel are based on the development of mathematical descriptions of travel as far as these were possible within the means available. Methods were devised to predict the number of journeys and to assign the journeys to the streets of 1959. By these means the volume of 1980 traffic can be described in relation to present streets, and specific problem areas in the street system can be located. The result of this assignment is the appearance of notable problem areas along the radial routes and in the central area of the city.

The most important mode of travel in 1980 will be the private car. The very large increase in the number of cars and their greater utilisation will be accompanied by a relative decline in the use of mass transportation, especially of the bus services. It is difficult to make a fair comparison of the average motorist and the average bus passenger in terms of costs.[1] For instance, the time taken for journeys depends very much upon how far the motorist has to walk after parking his car or, alternatively, how close the bus stop is to the home or intended destination. In particular cases a motorist may perhaps save 10, 20 or more minutes on a journey from suburb to city centre; the extent to which this saving of time influences individuals in their choice of transport, as between public bus or private car, will depend upon the value individuals set upon their time. For journeys made during the hours of paid employment time may, for general purposes, be valued in terms of the wages or salary earned. Journeys made in leisure time, or to and from work or on private business, are much more difficult to evaluate. One might

[1] Milage allowances payable for the use of cars and adult bus fares are stated in Appendix G.

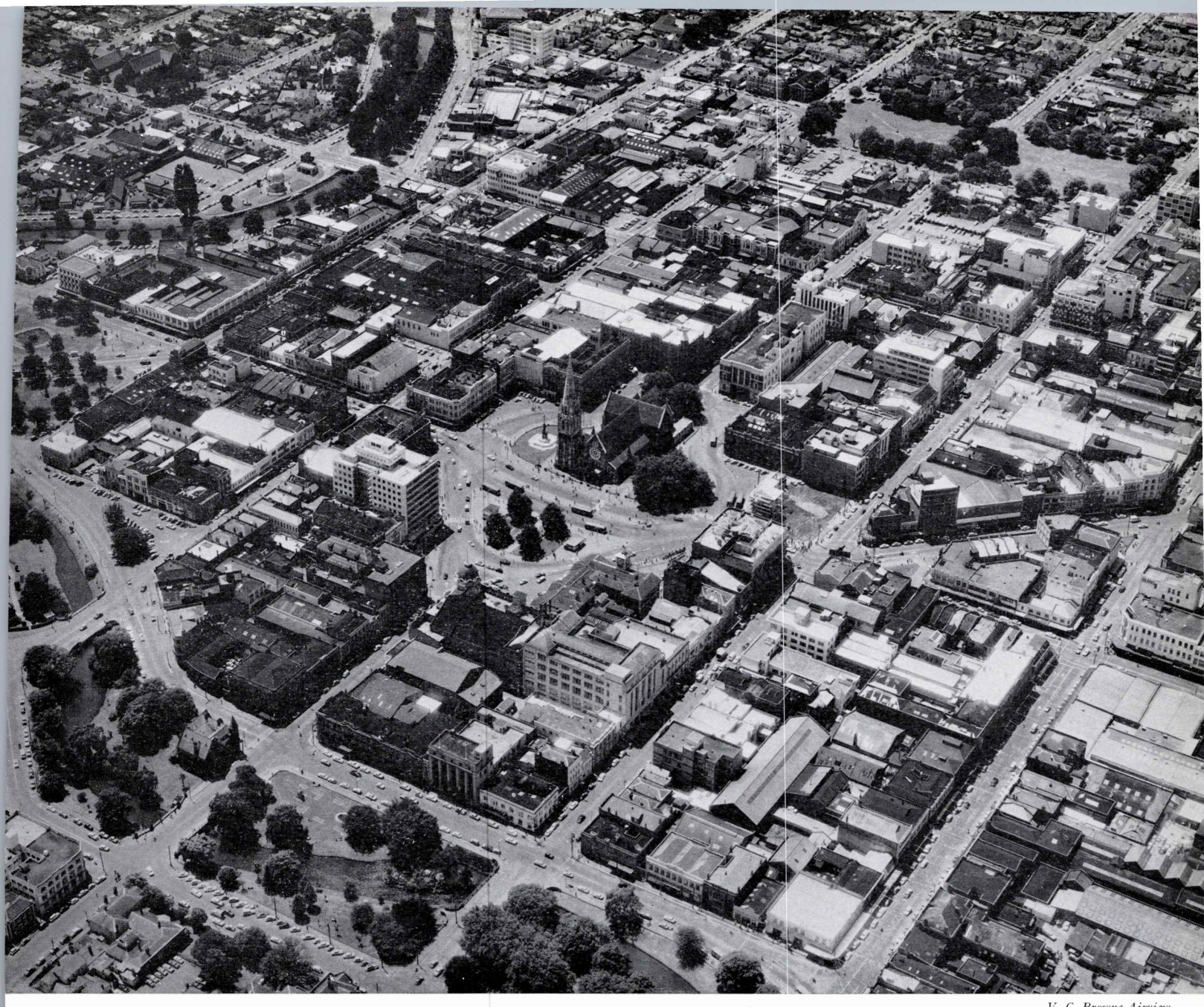


Reproduced from Original held at the Christchurch Office by the Department of Lands and Survey, by permission of the Department.

Plate XXVIII. The challenge in 1850—to create a town on the 'Plan of Christchurch, the Capital of the Settlement of Canterbury'.

presume that the time spent by the community at work and at leisure is in some sort of balanced relationship. Opportunity to do overtime work (at increased wages) is an incentive which draws workers to some fields of employment. However, there are usually some workers who prefer not to do overtime or who work less overtime than others; apparently, after a certain point, the personal value of their leisure is equal to the extra wages which might have been earned.

The doubling of traffic in the central area of the city is expected to create a demand for additional parking spaces equal to a rate of at least 500 a year for the two decades between 1959, the survey year, and 1980, the design year. Parking is already a pressing problem and has led to the con-



V. C. Browne Airview

Plate XXIX. The challenge now—to replan for growth, renewal, circulation, and prosperity.

struction of several parking buildings and many more will be required.

The traffic situation in the early years of the next two decades might be relieved by a number of temporary measures. The installation of more traffic signals and a system of one-way streets would ease congestion for a period. Another possible expedient is the extension of the principle of staggered working hours and, thereby, a reduction of peak hour traffic.

The reduction of peak hour traffic would have economic advantages for public transport services in particular. Bus companies report that peak travel continues to grow in relation to off-peak travel. This development increases the number of buses required to provide a satisfactory service

and therefore, operating costs are higher. It does not increase total revenue in the same proportion and makes it more difficult to run bus services economically. The staggering of working hours might help to arrest the tendency for operating costs to rise, by lowering peak travel and spreading the demand over a longer time period.

However, the staggering of working hours does not help in solving the parking problem. Half of the total parking space is required for persons who will be in the central area for most of the day; the remainder of the parkers, for example, shoppers, already have an incentive to shop early because of the greater ease in obtaining more convenient parking places. If the central business district and associated parking areas spread outwards, walking distances will increase. The incentive to park early and shop early seems likely to increase without conscious planning by the public authorities.

By means of detailed estimates of future traffic the consideration of planning needs has been extended two decades into the future and the temporary measures discussed above can be realistically assessed as nowhere near sufficient to serve the volume of traffic in 1980. The validity of this conclusion is seen in the assignment of traffic to 1959 streets and the assessment of these predicted traffic volumes against the design capacities of the present street system. It is, of course, possible to forecast further ahead than 1980 but the picture would become increasingly out of focus, the nature and location of problem areas would be much more difficult to describe, and the remedies would be more coarse in outline. Nevertheless, at various points in the present studies a look was cast further on in time but attention has been directed in this account only up to about 1980.

This does not mean that 1980 presents a static picture nor that the estimates will be realised according to a precise timetable. Continuous review is a necessary feature of planning for the future, and to provide a realistic basis for review a continuing programme of traffic counting is already in operation. Regular checks on intermediate forecasts for land use changes, economic and demographic growth, and vehicle usage must be made and the forecast for 1980 adjusted accordingly. What is described for 1980 is a predictable traffic situation which will arise about that time: in some parts of the city before the design year, in others possibly later.

The picture is now sufficiently in focus to indicate the challenge of the next two decades. The conclusion of the investigations—of the surveys, analysis and prediction of Christchurch traffic—is that *the present street system will require substantial modifications to meet the demands of the volume of traffic forecast for 1980.*[2] What is considered as the 'cost' of the modifications depends very much on the way in which it is viewed. If actual capital expenditure is to be the criterion, the modifications can be likened to the expansion of a city's water supply with substantial new reservoirs and a reticulation system on a large scale, so that the city will be in a position to meet the requirements of a much larger population in the future. Or the cost can be looked at from an investment aspect. There are undoubtedly real savings in travel costs resulting from high class roads. Indeed, it is often said that good roads are paid for whether we have them or not. In other words, lack of good roads means high transportation costs.

The outline of a transportation plan to meet the demands of the volume of traffic forecast for 1980 is already before the community. The challenge is the effective implementing of a transportation network that will serve the mounting need for travel. If urban traffic moves freely, easily, and in growing volume, the city will prosper in a way that will serve best the needs not only of the urban population but also of the rural community of which the city is an integral part.

[2] The nature and extent of these modifications depend upon further detailed investigations and these are beyond the scope of this publication.

Appendices

A. THE CHRISTCHURCH REGIONAL PLANNING AUTHORITY AND ITS RESPONSIBILITY FOR TRANSPORTATION PLANNING

THE Christchurch Regional Planning Authority was set up in 1955 under the Town and Country Planning Act 1953. Its Region incorporates, in whole or in part, the districts of eight territorial Councils (Fig. 69) and its main function is to prepare a planning scheme that will coordinate those developments, amenities and services that are of regional significance rather than of local importance to one Council only.[1] It is logical therefore, as well as being a requirement of the Act, for the Regional Planning Authority to be responsible for preparing a long term transportation plan for the Region.

THE BEGINNING

At the end of 1956, when considerable progress had been made on population and land use studies for the Region, the Authority started to consider the question of preparing a long term transportation plan. For this purpose it set up a Traffic Committee of technical personnel to study the best ways and means of preparing such a plan, having regard to the responsibilities of the uniting Councils and other organisations concerned with traffic and transport in the Region.

As the investigations progressed, it became abundantly clear to the Committee that a proper solution could only be achieved through a systematic investigation based on an origin and destination survey. The Committee also considered that, if the work was to be satisfactorily carried out, it would require the coordination of information, works and proposals throughout the Region, and the cooperation of all authorities concerned with traffic and transport. Because of the magnitude of the task, and to ensure support during the time it would take to prepare the plan, the Authority, in September 1958, convened a meeting of all interested organisations. The purpose of the meeting was to explain the position to all those concerned. It was attended by representatives of the uniting Councils of the Authority and of many other interested organisations and at its conclusion the following resolution was passed:

> 'That this meeting approves of the proposal that a Master Transportation Plan for Christchurch and environs be prepared as speedily as possible, and that to implement this proposal the Regional Planning Authority be recommended to set up an appropriate committee with adequate representation not exceeding twelve members in all.'

ORGANISATION AND STAFF

The Authority therefore decided to proceed at once with the preparation of a Master Transportation Plan for Christchurch and to take the necessary action to expedite the work.

In the first place, in 1958, the Authority, with a staff of ten, was not geared to undertake a full scale investigation of traffic and transport matters and at the same time carry on with its other regional planning studies and responsibilities. The chief executive officer and deputy were both town planners and there was a geographer on the staff. Therefore, provided regional planning studies not directly related to or essential for traffic investigations were, for the time being, set more or less on one side, it was considered that these three professional officers, together with the six draughtsmen of the staff, would, if augmented by an experienced engineer, be able to design and carry through the studies. Even so it was appreciated that from time to time considerable additional assistance of one kind or another would be needed, and the cooperation of all those who might be able to provide such assistance was sought and obtained.

Through the cooperation of the Ministry of Works which, on behalf of the National Roads Board, is responsible for national roading, Mr G. C. Suggate, a senior engineer, was released from the Ministry to work with the Authority. Mr Suggate acted as Investigating Engineer (Traffic and Transport) from January 1959 to June 1961; thereafter he returned to

[1] A more detailed description of the constitution, functions and organisation of the Regional Planning Authority may be found at the end of this Appendix.

the Ministry but continued to direct the studies until the Master Transportation Plan was published and adopted in principle in September 1962.

The next step was to set up, in the terms of the resolution passed at the meeting in September 1958, a Traffic and Transport Advisory Committee. This Committee, which met for the first time in February 1959, comprises representatives of the uniting Councils which are the local roading authorities; the Ministry of Works concerned with national roading and government departments responsible for railways and traffic administration; public transport and private haulage organisations, and other organisations and individuals with special interest in and knowledge of the problems concerned. The function of the Committee is to direct the preparation of the Master Transportation Plan and, subject to the final decision of the Authority, to deal with matters of policy. At the same time, and using the original Traffic Committee as a nucleus, a Technical Subcommittee was established to advise on and oversee the detailed investigations and design work involved in the preparation of the plan. The work then proceeded through its various stages.

The surveys were designed and organised by the staff of the Authority but were carried out with the assistance of many organisations, as listed below, and with some 20 to 30 additional temporary, paid staff. These were more especially employed for the delivery and collection of the forms for the Home Questionnaire Survey, for some of the coding of the collected data and for assisting with the additional typing required.

STAFFING OF SURVEYS

Name of Survey	*Field Organisation and Staff*
Home Questionnaire	Regional Planning Authority using its own and 20 temporary staff.
External Cordon Interview	Transport Department with the help of Army personnel.
Internal Cordon Count	Christchurch City Council Engineer's Department.
Transverse Screen Line Count	Christchurch City Council Engineer's Department, Riccarton Borough Council and Paparua County Council with the assistance of staff of the Ministry of Works and the Department of Lands and Survey.
Machine Traffic Counting	For four weeks: Christchurch City Council Engineer's Department, the Waimairi County Council and the Transport Department. For six weeks: Ministry of Works using their own counters together with those of the above bodies and the Akaroa County Council.
Parking Accumulation	(a) On Street. Christchurch City Council Traffic Department. (b) Off Street. Regional Planning Authority with staff of the Waimairi County Council, Ministry of Works and the Department of Lands and Survey.
Christchurch Transport Board Bus Passenger Load Data	Christchurch Transport Board.
Other Passenger Load Data	Midland Motorways, Days Motors, New Zealand Railway Road Services and the New Zealand Railways.
Passenger Origin and Destination Data	Regional Planning Authority Questionnaire Cards issued to passengers by Midland Motorways, Days Motors, New Zealand Railway Road Services and the New Zealand Railways.
Taxi Travel	Regional Planning Authority Log Sheets issued to Blue Star and Gold Band Taxis.
Trade Vehicle Travel	Regional Planning Authority Log Sheets issued to a 12½ per cent sample of trade vehicles. The Log Sheets were collected by the Regional Planning Authority, assisted by staff of Riccarton Borough Council, Paparua County Council, Waimairi County Council, Ministry of Works and members of the road transport and carriers' organisations.

After the survey data had been coded by the Authority's staff, it was punched on to cards, sorted and tabulated by the Ministry of Works in Wellington. The analyses of data, and the forecasting and assignment work were carried out wholly by the staff of the Authority, with two exceptions. These were the Internal Cordon Count and the Parking Surveys, the analyses of which were undertaken by the Christchurch City Council.

In the mathematical and statistical work concerned with the derivation of formulae, the Authority was very greatly assisted by Dr B. I. Hayman. Dr Hayman was, at the time, stationed some 14 miles from Christchurch with the Applied Mathematics Division of the Department of Scientific and Industrial Research at Lincoln. He was in frequent consultation with the Authority's officers and, in effect, was responsible for the derivation of all formulae used.

The calculations of future trip generation for all subsectors and localities were done manually by the staff of the Authority. The next step was the distribution between subsectors of the future trips so calculated. This, with the exception of the distribution of trips to and from the Central Traffic District, was programmed and carried out by the Applied Mathematics Division of the Department of Scientific and Industrial Research in Wellington with the aid of an electronic computer. The assignment of future intersubsector travel to the existing street system was then done manually by the staff of the Authority.

Throughout the surveys the advice and assistance received from members of the Traffic and Transport Advisory Committee, especially its Technical Subcommittee, contributed greatly to the successful completion of the work.

ACKNOWLEDGEMENTS

In a study of such magnitude and importance and because of its limited staff and financial resources the Authority had of necessity to call upon a large number of organisations and individuals for assistance and advice at all stages of the work. Without their cooperation the surveys could not have been undertaken. In particular, mention must be made of the people of Christchurch and visitors who responded so readily to the many requests for information which eventually showed how, where, why and when journeys were made. The assistance of the press and radio is gratefully acknowledged and both organisations gave the field surveys wide publicity. This contributed substantially to a greater public understanding of the work and assisted in the cooperation that was received.

To the following persons and organisations the Christchurch Regional Planning Authority expresses its appreciation:

To Ministry of Works at Wellington and Christchurch
for general support and assistance throughout the investigations and, in particular, for releasing a senior engineer to direct the investigations and for advising on and undertaking the punching, sorting and tabulating of survey data under the direction of Mr J. H. Havill, of the Chief Accountant's Office, Wellington.

For general support and assistance throughout the investigations:

to Councils and Officers of the districts within the Christchurch Region namely:
Christchurch City Council
Kaiapoi Borough Council
Riccarton Borough Council
Eyre County Council
Halswell County Council
Heathcote County Council
Paparua County Council
Waimairi County Council

and to Christchurch Transport Board
New Zealand Railways, Christchurch
Transport Department, Christchurch

For assistance in carrying out surveys:

to Akaroa Borough Council (now merged with the Akaroa County Council)
Army Department, District Commander, Southern Military District
Registrar of Motor Vehicles, Christchurch
New Zealand Railway Road Services, Christchurch
Department of Lands and Survey, Christchurch
Days Motors Limited
Midland Motorways Services Limited
Blue Star Taxis
Gold Band Taxis
The New Zealand Road Transport Alliance, Christchurch
The Christchurch and Suburban Carriers and Customs House Agents Association, Incorporated
John Brightling Limited
Central Carrying Company Limited
J. Deyell and Company Limited
A. R. Guthrey and Company Limited
Gwatkin C. E. and Company Limited

Horton Bidwell and Company Limited
D. A. R. McBeth
Percy Moore
Musgrove Brothers Limited
The New Zealand Express Company Limited
W. Whittaker and Company Limited
C. Williams and Sons Limited

To Department of Scientific and Industrial Research and in particular **for** the considerable amount of work undertaken in the statistical analysis and derivation of formulae by Dr B. I. Hayman, then of Applied Mathematics Division (now Professor of Mathematics, Massey University of Manawatu), and for undertaking electronic computer work on the distribution of 1980 intersubsector travel.

To Associate Professor W. R. Andress, Department of Mathematics, University of Canterbury, **for** guidance and assistance in the initial analysis of survey information.

To *The Christchurch Star*
The Press, Christchurch
New Zealand Broadcasting Service, Christchurch (now New Zealand Broadcasting Corporation) **for** publicity on the field surveys.

In addition the Authority acknowledges the help given by many organisations and individuals who by their published and unpublished investigations have contributed to the knowledge of traffic and transport and related matters. Their experience has been freely called upon in studying the traffic problems of Christchurch.

THE AUTHORITY

The Christchurch Regional Planning Authority was formally constituted in June 1955 under Section 7 of the Town and Country Planning Act 1953, after each of the six Councils concerned at the time had resolved to unite for the purpose of preparing a regional planning scheme. The area to be covered by the regional planning scheme comprised all of Christchurch City, Riccarton Borough, and the Counties of Heathcote and Waimairi together with parts of Halswell and Paparua Counties. In March 1956 a further part of Paparua County was added and in November 1958 the Borough of Kaiapoi and part of Eyre County were included. The boundaries of the districts of the uniting Councils comprising the Christchurch Region, and the boundary of the Region, are shown in Figure 69.

REPRESENTATION

Representation on any Regional Planning Authority is governed by Sections 8 and 9 of the Town and Country Planning Act 1953 which provide for representation by members from the uniting councils and by associate members from other special purpose or ad hoc local authorities. In addition, an Authority may appoint as an associate member any person who may be possessed of special knowledge of advantage to the Authority. Only Councils' representatives have the right to vote at any meeting of the Authority.

Representation on the Christchurch Regional Planning Authority covers the eight uniting Councils, which have a total of eleven members, four from Christchurch City and one from each of the other seven Councils. In addition, nine local authorities, four government departments and the Canterbury Branch of the New Zealand Institute of Architects are each represented on the Authority by one associate member. The Authority has also invited an engineer to be an associate member in a private capacity. The Chairmen of Advisory Committees are associate members ex officio.

FUNCTIONS AND POWERS

The Christchurch Regional Planning Authority is a special purpose organisation set up to prepare a regional planning scheme, and to undertake other town planning and related functions for all or parts of the districts of the eight territorial Councils. It is not primarily concerned with detailed or day to day town planning work, except in offering guidance or assistance where this is sought or where such work may have a wider regional significance, that is beyond the district of the Council concerned.

The Town and Country Planning Act 1953 prescribes as follows:

Section 3(1):

'Every regional planning scheme shall have for its general purpose the conservation and economic development of the region to which it relates by means of the classification of the lands comprised therein for the purposes for which they are best suited by nature or for which they can best be adapted, and the co-ordination of all such public improvements, utilities, services, and amenities as are not limited by the boundaries of the district of any one local authority, or do not relate exclusively to the development of any one such district.'

Section 3(2):

'Every regional planning scheme shall be designed as a guide to Councils engaged in the preparation

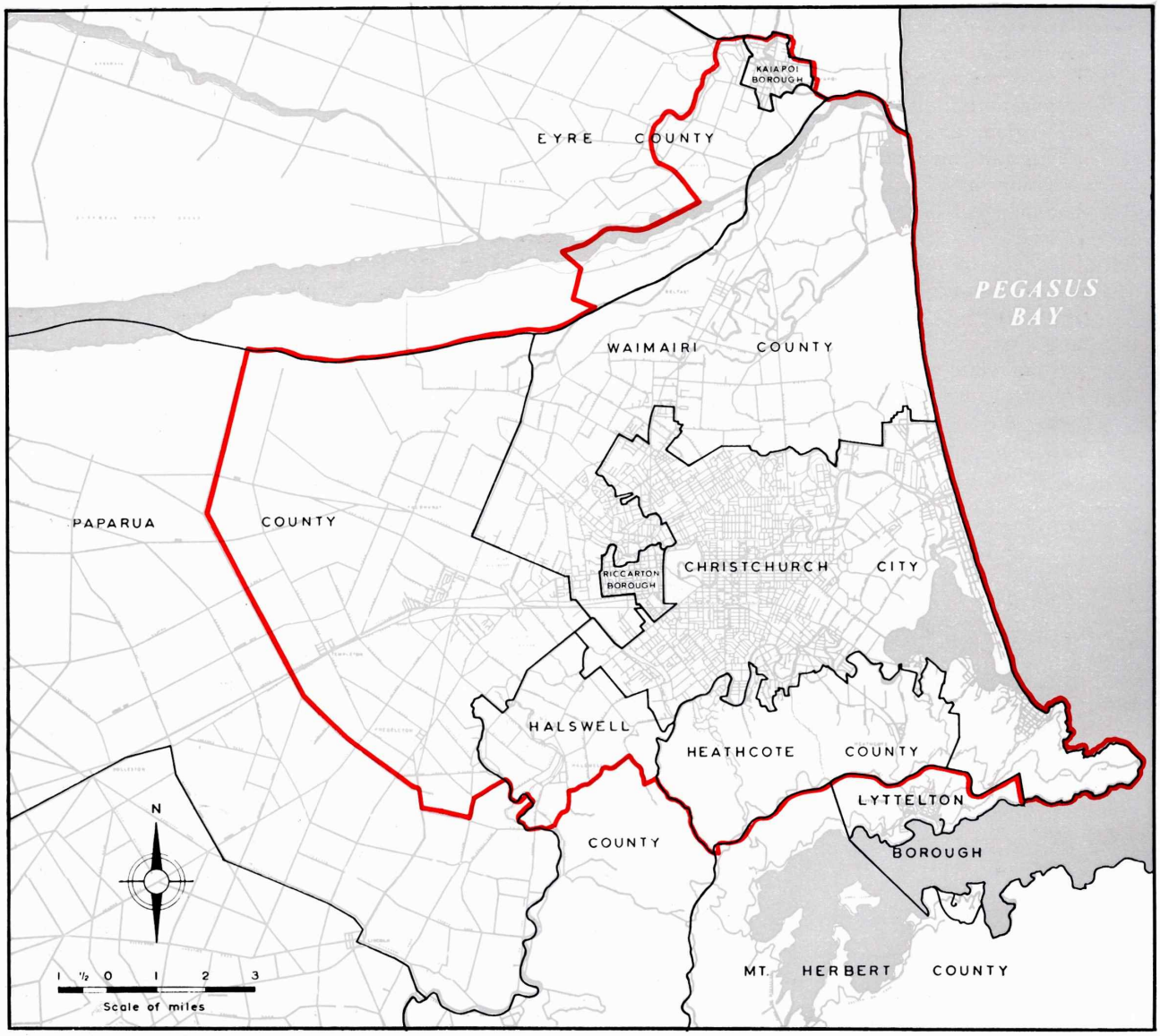


Fig. 69. CHRISTCHURCH PLANNING REGION, 1959. The boundary of the Planning Region is in red.

of district schemes, and also as a guide to public authorities and local authorities and all persons in relation to the conservation or development within the region of the public utilities, services, industries, amenities, and other matters dealt with or adverted to in the regional planning scheme.'

When a regional planning scheme has become operative, the Act provides in Section 4(1) that every public body and local authority in the performance of its public duties and functions shall adhere to it, subject to the rights of appeal which are prescribed in the Act.

Section 12(2):

'Additional functions of the Regional Planning Authority after, and (so far as they are applicable) before, the completion of the regional planning scheme shall be:

(a) To review the scheme from time to time as required by this Act:
(b) To make recommendations with respect to the preparation of district schemes for areas within the region; and, where it thinks it necessary, to lodge an objection or appeal in respect of any provision in a district scheme that conflicts with any provision in the regional planning scheme:
(c) To advise or make recommendations to local authorities and other persons and bodies concerned in the operation of any regional planning scheme or district scheme in respect of any matters relative thereto:
(d) To assist as far as it may in the consideration of town and country planning within its region and other regions and districts.'

ORGANISATION

The Christchurch Regional Planning Authority has set up an Executive Committee and two Advisory Committees to carry out its functions and responsibilities. The Executive Committee, which comprises representatives of the eight uniting Councils, is responsible for financial and office administration and considers all recommendations of Advisory Committees before they are submitted to the Authority in open meeting for discussion and final decision.

The Technical Advisory Committee is composed of the technical representatives of the uniting Councils, usually the engineer or town planning officer, together with technical officers from some special purpose authorities and government departments. The Committee's function is to undertake investigations and make recommendations on all planning matters. The Committee has several subcommittees to assist it in carrying out this work.

The Traffic and Transport Advisory Committee consists of representatives of organisations directly concerned with traffic and transport matters. Details of its composition and functions, together with those of its Technical Subcommittee, were described in the earlier section of this Appendix.

In addition to these Committees directly concerned with planning matters there are two other Committees which function within the framework of the Authority. One is the Air Pollution Advisory Committee which has been set up by joint agreement of the uniting Councils to investigate air pollution matters in the Region and to act as the local branch of the National Air Pollution Committee of the Board of Health. The other is the Committee which has been set up in terms of the Summit Road (Canterbury) Protection Act 1963 by which the Authority is charged with the responsibility for preserving and protecting the scenic amenities associated with the Summit Road and other roads in the Port Hills, on Banks Peninsula, in Canterbury and for providing for the improvement of facilities for the public enjoyment of these amenities.

B. THE CHRISTCHURCH CENTRAL BUSINESS DISTRICT

THE CENTRE of Christchurch is on a flat site and built to a chequer board pattern, broken somewhat by the meandering course of the River Avon, the diagonal route of the old main road and by Cathedral Square which widens a main intersection and provides a setting for the cathedral of the Anglican Church. The central business district, as shown in Figure 70, is located around Cathedral Square and contains 47 street blocks of varying size of which the largest, rectangular in shape, are five acres and a half in area and measure 726 feet by 330 feet.

The grouping of shops, offices and other uses is generally well defined in the 'core' of the business district around Cathedral Square but in the fringe areas there is an ill-defined mixture of all land uses. This is particularly true to the east where the central business district adjoins a residential area, but less so to the west where the River Avon has tended to obstruct the spread of commercial uses into a mixed residential and educational precinct.

The central business district contains 10 million square feet of floor space of which a little more than half is at ground level. The density of building is generally low with a slight concentration in the blocks to the east and south of Cathedral Square but in only one street block is there three times as much floor space as ground area. The greatest users of floor space, as shown in Table 34, are shops, industry and offices in that order, but, while about half the industry is located in the southern part of the district, almost all the shops and offices are concentrated in the core about Cathedral Square.

The relationship between the central business district of Christchurch and the remainder of the built-up area closely resembles that for cities of similar size in the United States of America. Selected statistics are averaged for 14 American cities within a population grouping of 100,000 to 250,000 and compared to Christchurch in Table 35.

TABLE 34

THE CENTRAL BUSINESS DISTRICT OF CHRISTCHURCH: FLOOR SPACE USAGE, 1960

USE CATEGORY	GROUND FLOOR		OTHER FLOORS		TOTAL	
	Area (000's sq. ft.)	%	*Area (000's sq. ft.)*	%	*Area (000's sq. ft.)*	%
Shops (retail, wholesale)	2124	41	1598	36	3722	38
Industry	1387	27	838	18	2225	23
Offices	553	11	1137	26	1690	17
Public Use (excl. offices)	211	4	244	5	454	5
Entertainment	138	3	107	2	245	3
Transport and Communications (excl. offices)	249	5	67	1	316	3
Storage	119	2	41	1	160	2
Utility Services (excl. offices)	52	1	22	0	74	1
Residential	280	5	431	9	711	7
Vacant	46	1	97	2	144	1
TOTAL	5159	100	4582	100	9741	100

TABLE 35

RELATIONSHIP OF THE CENTRAL BUSINESS DISTRICT AND THE BUILT-UP AREA: CHRISTCHURCH COMPARED TO SELECTED AMERICAN CITIES

ITEM	*American City**	*Christchurch*†
Urban Population	100,000-250,000	208,100
Built-up Area	38.60 sq. ml.	36.70 sq. ml.
Area of C.B.D.	0.38 sq. ml.	0.42 sq. ml.
C.B.D. as percentage of Built-up Area	1.1%	1.1%
Area of C.B.D., per 100,000 Urban Population ..	0.24 sq. ml.	0.20 sq. ml.

* *Parking Guide for Cities*, published by U.S. Department of Commerce, Bureau of Public Roads, Washington, 1956, page 11.
The data for cities in the 100,000 to 250,000 population grouping are averaged results from 14 cities with an average urban area population of 167,000 in 1950.

† Data is for 1961.

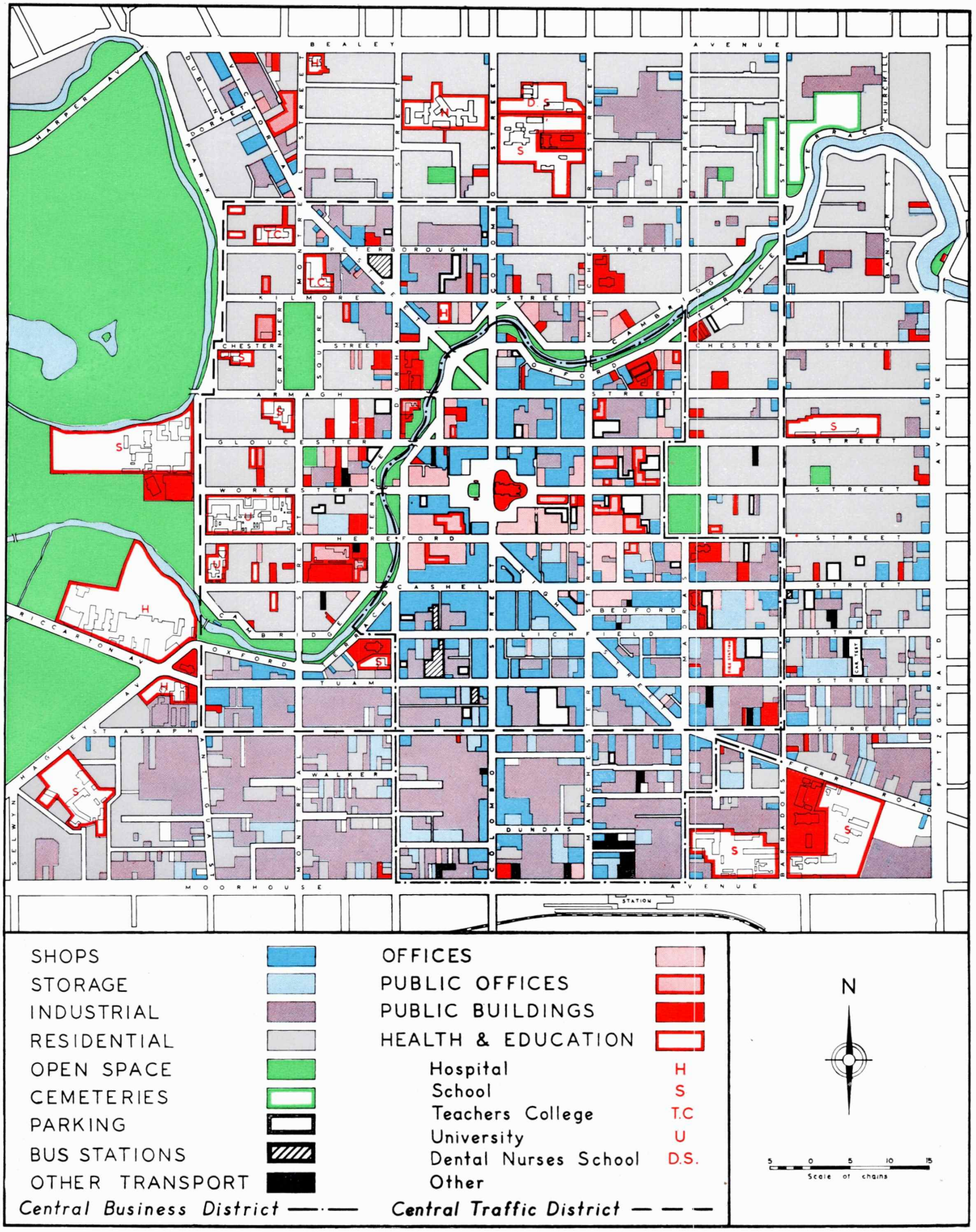


Fig. 70. Land use in the inner city, 1956.

C. TRAVEL AND TRAFFIC SURVEYS CARRIED OUT IN SEPTEMBER-OCTOBER, 1959

THIS Appendix summarises the purpose and type of surveys, the way in which they were carried out and the method of analysis.

PURPOSE

Some of the most important information that was required, concerned the origin and destination of all journeys or trips and, in each case, the form of transport used and the time and purpose of the trip. In this context, journeys or trips include not only vehicles, both goods and passenger, but also passengers in cars, buses, local trains and taxis.

It was expected that this information would indicate, amongst other things, the places between which the major traffic flows were occurring at the time of survey, and the magnitude of these flows. Thus would emerge a basis on which to assess the size and location of major routes in the future and also the possible value of such facilities as bypasses either for the central business district or for the built-up area as a whole.

The surveys would also provide important information about parking such as the demand for long or short term parking, where these demands were occurring, and the numbers of vehicles involved. This in turn would provide a basis for assessing the type, location and size of future parking facilities.

TYPE

To provide the information required, a group of ten surveys were carried out over a period of ten weeks from the middle of August to the middle of October although most of the surveys were concentrated within a three week period from the last week in September to the second week in October. Throughout the whole ten week period however there was a systematic and repeating programme of mechanical counting for selected days at almost all stations. The results of this programme permitted a comparison of one week against another, and one day against another, thereby providing a check on the major surveys which were largely confined to a particular day of a three week period.

The surveys fell, broadly, into three main groups. One, the Travel Surveys, covered those surveys which sought specific information about individual trips. The second, the Traffic Surveys, assembled information about moving vehicles and their passengers that could be recorded manually or by mechanical traffic counting machines. The third, the Parking Surveys, assembled information about the stationary vehicle that could be recorded by observation.

The territory covered by the surveys was divided into two main areas. The first, and the major one, is the built-up or Internal Area comprising about 60,000 households. As it was important to be able to trace the origins and destinations of vehicles moving about within the built-up area, this area was divided into 10 sectors which were further subdivided into subsectors each containing about 1,000 households. In all there were 59 subsectors. There were some instances in which it was thought that it might be necessary to examine the information from the surveys in relation to even smaller areas than that of subsectors and therefore some of the subsectors were further subdivided. This meant that all the information collected could thereafter, as required, be related to any one subsector or to any group of the 59 subsectors. For example it would be possible to calculate not only the number of trips that emanate from any particular subsector but also the number of vehicles and people involved, the purposes for which they were travelling and the places to which they were going. The second area, known as the External Area, lies outside the built-up or Internal Area and information was obtained regarding the vehicles that travel between these two areas.

One of the subsectors of the built-up area was made the subject of special investigations. This area covered what is known as the Central Traffic District which includes a large part of the central business district plus an additional area of land affected by parking associated with the central business district.

These three areas, the Internal Area, External Area and Central Traffic District, were divided one

from the other by defined boundaries or lines. That dividing the built-up area from the districts and localities outside was known as the External Cordon Line and that circumscribing the Central Traffic District was known as the Internal Cordon Line. Between these two an intermediate line, the Belt Cordon Line, was located immediately outside the city Belts. This latter line was used for collecting certain limited information regarding traffic flows.

The Travel Surveys sought specific information about individual trips. These were the surveys that collected information on such things as the origin and destination of each trip, the purpose for which the trip was undertaken, the form of transport used, and the time at which a trip was made. They can be divided into two groups as follows:

(a) Surveys concerned with vehicles and people who came into the built-up area from outside. This information was collected in two ways as follows:
   (i) by setting up interview stations at the External Cordon Line on 14 of the main roads, and interviewing the drivers of a 50 per cent sample of vehicles entering and leaving the built-up area (External Cordon Interview Survey);
   (ii) by issuing questionnaire reply-paid postcards to travellers who crossed the External Cordon Line in buses and local trains (Bus and Train Passenger Questionnaire Survey).

(b) Surveys concerned with trips made by residents and by vehicles housed inside the built-up area. This information was collected in two ways as follows:
   (i) by the issue of questionnaire forms to every member of 3000 households which comprised a carefully selected five per cent random sample of all households within the built-up area (Home Questionnaire Survey). An example of the Home Questionnaire is reproduced in this Appendix.
   (ii) by the issue of special log sheets to a 20 per cent sample of taxis and to 900 trade vehicles comprising a random 12½ per cent sample of those in the area (Taxi and Trade Vehicle Surveys).

The Traffic Surveys were undertaken manually or by mechanical traffic counting machines. These all involved the counting of vehicles or people and comprised the following:

(a) The number and type of motor vehicles and passengers therein crossing the External Cordon Line (External Cordon Count supplemented by machine counts and Bus and Train Passenger Load Data).
(b) The number and type of motor vehicles, and the number of people in them, crossing the Internal Cordon Line, together with pedal cycles and pedestrians (Internal Cordon Count made on a sample basis supplemented by machine counts and Bus Passenger Load Data).
(c) The numerical machine count of motor vehicles crossing the Belt Cordon Line (Belt Cordon Count).
(d) The number and type of vehicles crossing a line drawn across the city from east to west so that all vehicles moving north and south would have to cross it. Vehicles were counted manually on a selected group of roads supplemented for all other roads by machine counts (Transverse Screen Line Count).
   The Transverse Screen Line Count was undertaken for the special purpose of providing a means of checking the Travel Surveys which were made on a sample basis only.

The four Traffic Surveys (a) to (d) inclusive provided information about traffic volumes in various parts of the town. All the Traffic Surveys, in greater or lesser degree, provided a means of checking the results from the Travel Surveys which were made on a sample basis only. The survey points are located and classified in Figure 71.

The Parking Surveys recorded the number, type and location of all stationary vehicles parked both on and off the street within the Central Traffic District at hourly intervals. These parking surveys were aimed at determining the accumulation of vehicles in the area throughout a 12 hour day, and the degree to which parking space was in demand; they also aimed at making comparisons with the Travel Survey results which in their turn yielded information on the duration of and reasons for parking.

OPERATION

The planning of the surveys was a major operation. It occupied most of the staff of the Christchurch Regional Planning Authority for some six months and required considerable assistance from the Traffic and Transport Technical Subcommittee and a study group set up by the Subcommittee. Details were received from time to time by the Traffic and Transport Advisory Committee for comment until finally

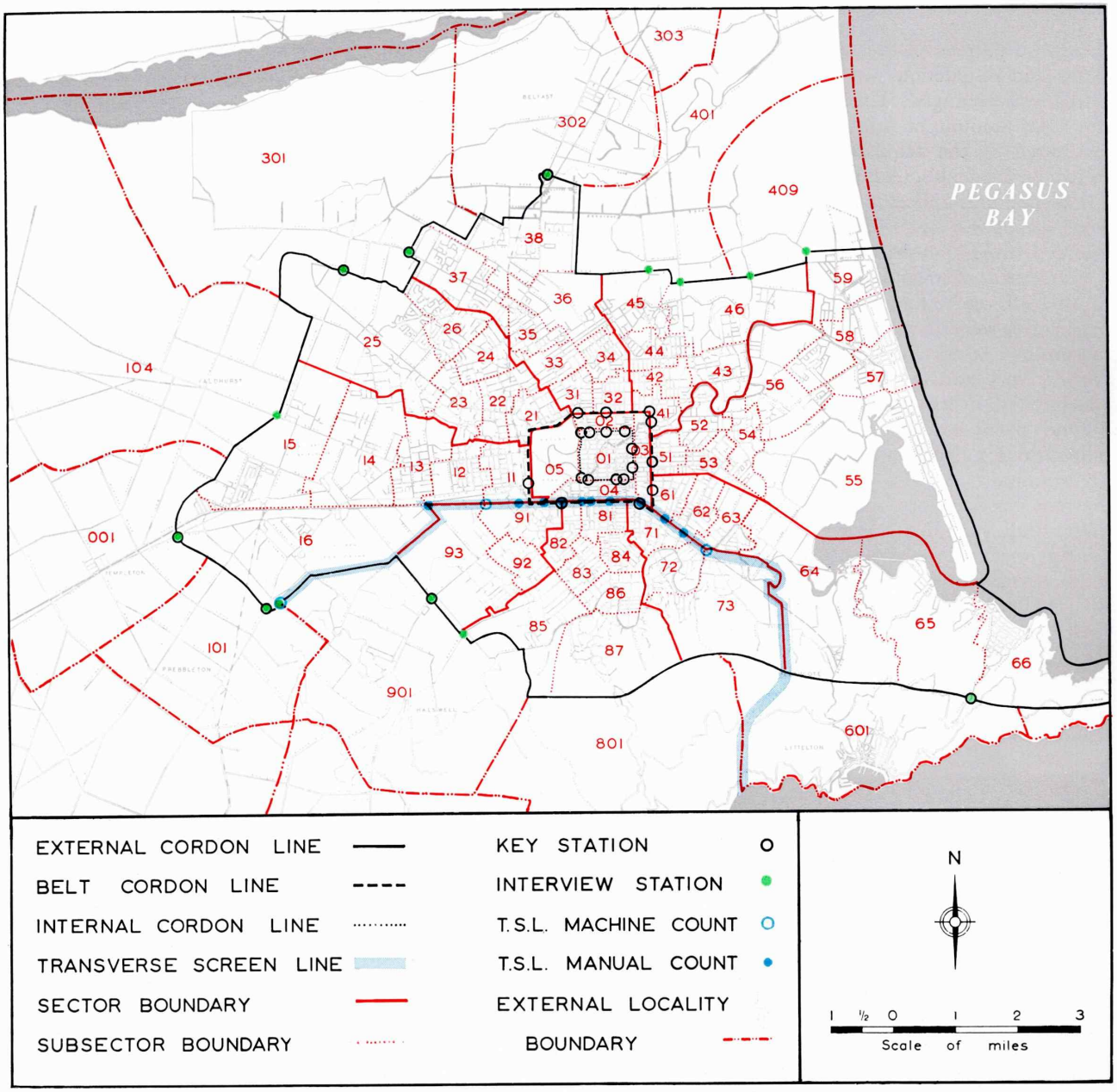


Fig. 71. 1959 SURVEYS: CORDON LINES AND SURVEY POINTS. In addition to the survey points shown on this map, there were counting stations at all other streets crossing the External, Belt, and Internal Cordon Lines; these additional survey points are included below in Other Stations.

Machine Counts: *Key Stations* were used to expand sample counts of other stations with traffic of similar characteristics. At each Key Station automatic machine counts were made, hour by hour, for one or two full weeks during the ten week survey period and, for each of the remaining weeks, there was one or more 24 hour weekday machine count. Key Stations on the Belt Cordon Line had, in addition, two or more full weeks of 24 hour machine counts.

Other Stations had one or more 24 hour weekday machine counts during the ten week period.

(continued at foot of page 183)

the entire pattern of the surveys was arrived at, the forms and instructions were prepared and the manpower was arranged. This planning involved a considerable amount of original work but was greatly facilitated by the acquisition of Procedure Manuals issued by the Public Administration Service, U.S.A.[1] These manuals reflect many years of experience in this type of work and although the methods recommended were not followed in every respect the general procedure and principles laid down proved of the utmost value. Departures from established procedures were necessary in some instances primarily to conserve resources, to minimise the time required for the work and to make use of such manpower as was likely to be available.

One particular departure was the decision to deliver and collect questionnaire forms in the Home Questionnaire Survey instead of employing interviewers. Furthermore, instead of spreading enquiries over a full year this survey was carried out over a period of three weeks and answers were sought in respect of a particular day of the week. The reasons for this decision were that in the first place reliable interviewing would have required a team of highly trained interviewers and such was not available in New Zealand, but some measure of the success of the method adopted can be gauged from the fact that the proportion of refusals or failures to fill in forms was only two and a half per cent. In the second place, the concentration of the work into three weeks meant much earlier completion and much greater efficiency in carrying out the operation. The day of the week and season of year chosen—a Wednesday in the Spring—were considered to represent average conditions as is borne out by the extended programme of traffic counts. The designing of a satisfactory questionnaire form was in itself a lengthy process of trial and error, and the picking of the sample of households to be approached was a long and laborious task, but nevertheless the whole of the survey work was completed in seven to eight months.

To ensure that the travel surveys would succeed in their various objects, a series of trials was run three months before the major programme was planned to start. These proved most useful and also showed, beyond expectation, the degree of cooperation which could be expected from the travelling public. Mention must be made of the significant assistance given by press and radio in publicising the need for the surveys, the importance attached to them, and the extent to which public cooperation was essential to their success.

For the planning of the final details of the surveys, especially in regard to manpower, the Traffic and Transport Technical Subcommittee set up a study group through which was sought and willingly given the assistance of local authority and Government Department staff, helped in the case of the roadside interviews by the Army Department. The Authority itself took on 20 temporary staff for three weeks to undertake the delivery, collection, checking and coding of Home Questionnaire forms. At the height of the surveys, the number of people actively engaged in field work was approximately 140. Further details on staffing are in Appendix A.

[1] *Better Transportation for Your City—A Guide to the Factual Development of Urban Transportation Plans Accompanied by a Series of Procedure Manuals*, Public Administration Service, U.S. Department of Commerce and Bureau of Public Roads, Chicago, 1958.

(*Fig. 71 continued*)

Additional Surveys: *External Cordon Interview Stations* had an interview of a 50 per cent sample of in and out traffic (except pedestrians, bicycles and public transport) for 12 hours (6.30 a.m.-6.30 p.m.) on a Wednesday in one of three weeks: and during the same day and same period, a classified manual count of vehicles (including bicycles) by half hour periods.

Internal Cordon Line (*Key and Other Stations*) had a manual sample count for six minutes in every hour for 12 hours (6.30 a.m.-6.30 p.m.) on the same Wednesday on every street and of all types of traffic (including pedestrians).

Transverse Screen Line: Stations on the section of the Transverse Screen Line coinciding with the Belt Cordon Line, had machine counts as described above. Other Stations on the remainder of the Transverse Screen Line had two 24 hour machine counts on weekdays during a three week period. At selected points (Transverse Screen Line Manual Count Stations) there was a classified manual count of vehicles only, by quarter hour periods, for 12 hours (6.30 a.m.-6.30 p.m.) on the same Wednesday.

ANALYSIS

Because of the volume of data obtained by the surveys, analysis was possible only by the use of punched cards which were sorted by machine into any desired grouping. After sorting, the cards were fed through tabulating machines which printed the desired information ready for the preparation of statistical tables. Punching, sorting and tabulating were carried out by the Ministry of Works, Wellington. As punched cards depend on all items of information being in terms of numerical codes, it was first necessary to translate the answers given in questionnaires, interviews and log sheets into suitably coded form. This work, which had to be done before punching could commence, was carried out by the Authority's staff. The above applies to the Travel Survey material, but the Internal Cordon Count and Parking Survey material was handled by the City Engineer's Department of the Christchurch City Council.

CHRISTCHURCH REGIONAL PLANNING AUTHORITY

143b Worcester Street. Telephone 76-036
76-037

CHRISTCHURCH

MASTER TRANSPORTATION PLAN

TRAVEL SURVEY

You have received a letter about this Traffic Survey.

Your help in filling in these forms, one for each member of the household, will be very much appreciated.

Your answers will be kept confidential.

There are some explanatory notes and a map on the last page.

Thank you for your co-operation.

Mary McLean
Chairman, Traffic and
Transport Advisory Committee

CHRISTCHURCH
September, 1959

All Information on this Form is for WEDNESDAY, 30 SEPTEMBER 1959

Mark Your Answers with an "X" unless otherwise stated.

For the **TRIP TO WORK OR SCHOOL** on
WEDNESDAY OF THIS WEEK

DID YOU GO TO

Work ☐ School ☐ Neither ☐
(Mark the square which applies to you).

WHERE DID YOU GO?

(If more than one place give first only).

Give Name and Address of
Firm, School, etc.,
or Street Name and No.

WHAT TIME DID YOU

(Do not include trips to and from home for Lunch etc.).

Leave Home?	
Arrive Home?	

HOW DID YOU GO?

	To WORK ETC.	From WORK ETC.
1. Drove Car, Truck, etc.		
2. Car Passenger		
3. Truck/Van Passenger		
4. Taxi Passenger		
5. Bus Passenger		
6. Motor or Power Cycle		
7. Pedal Cycle		
8. Train		
9. Walk		

IF YOU DROVE A CAR TO WORK

1. Where did you park it?

On Street	
Off Street	

2. Why did you take it?

Personal Transport only	
Business Use as well as Personal Transport	

FOR WHOM IS THIS FORM BEING FILLED IN?

Mark the square for whom this Form is being filled in.
Children under 3 years not included.

HUSBAND ☐ **SON** ☐ **OTHER** ☐

WIFE ☐ **DAUGHTER** ☐

SUBSECTOR
SERIAL No.

For **ALL OTHER TRIPS** on

WEDNESDAY OF THIS WEEK

TO BE FILLED IN whether or not you go to Work or School but do not include the trip to and from Work or School which you fill in on the opposite page.

NOT TO BE FILLED IN:—

1. by persons driving TRUCKS, VANS, BUSES or TAXIS on business trips or for BICYCLE DELIVERIES. This information is being obtained in other ways. (Station wagons, whether L plates or not, are CARS for the purpose of this Form).
2. for short distance trips, i.e. less than about ½ a mile.
3. for children under 3 years of age.

IF YOU HAVE NO TRIPS TO FILL IN ON THIS PAGE MARK THIS SQUARE ☐

WHERE DID YOU GO?

Use "City Centre", "East Central" etc., as names for Districts in the area covered by the Map (attached). In "City Centre", names of Streets may be omitted.

Those at Work or School should put "Home" for trips home during the day for lunch, etc.

TRIP	PLACE VISITED		APPROX. TIME ARRIVED AT PLACE VISITED	APPROX. TIME DEPARTED FROM PLACE VISITED	WHERE DID YOU PARK YOUR CAR (IF ANY)?	
	NAME OF DISTRICT	NAME OF STREET			ON STREET	OFF STREET
1st						
2nd						
3rd						
4th						
5th						
6th						
7th						
8th						

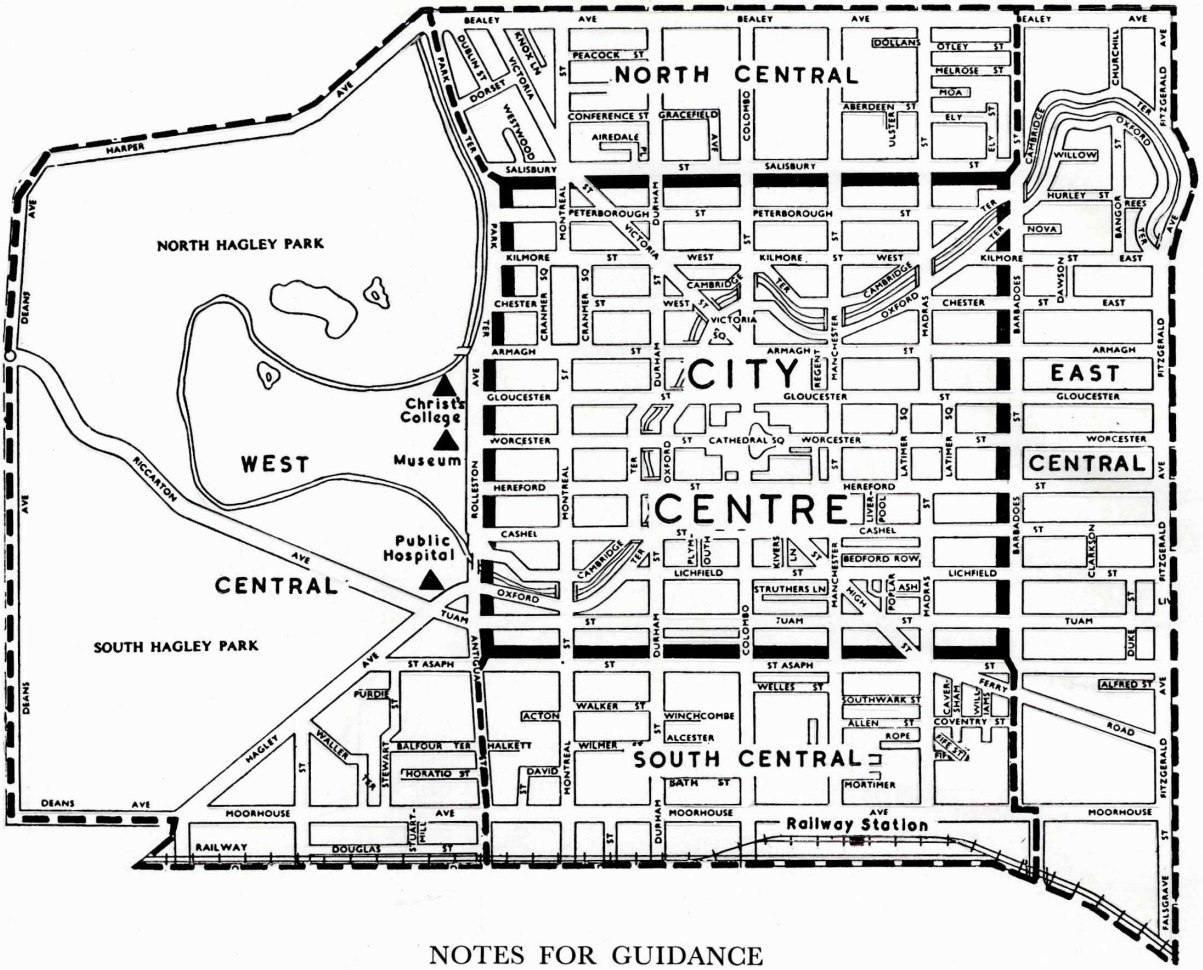
WHY DID YOU GO?

Give the main purpose of each trip.

	1st TRIP	2nd TRIP	3rd TRIP	4th TRIP	5th TRIP	6th TRIP	7th TRIP	8th TRIP
1. On Work or Firm's Business								
2. Shopping								
3. Personal Business								
4. Social, Recreational								
5. Breakfast, lunch, dinner								
6. Picking up or putting down a passenger								

HOW DID YOU GO?

	1st TRIP		2nd TRIP		3rd TRIP		4th TRIP		5th TRIP		6th TRIP		7th TRIP		8th TRIP	
	TO	FROM	TO	FROM	TO	FROM	TO	FROM	TO	FROM	TO	FROM	TO	FROM	TO	FROM
1. Drove Car, Truck, etc.																
2. Car Passenger																
3. Truck/Van Passenger																
4. Taxi Passenger																
5. Bus Passenger																
6. Motor or Power Cycle																
7. Pedal Cycle																
8. Train																
9. Walk																



NOTES FOR GUIDANCE

Left Hand Page of Form

For the TRIP TO WORK OR SCHOOL

Mark the square "WORK" or "SCHOOL", whichever is appropriate.

If you did not go to Work or School on Wednesday of this week mark the square "NEITHER" and do not attempt to answer the other questions about the trip to Work or School.

DID YOU GO TO—WORK?
SCHOOL?

"Work" also includes commercial college, university etc. "School" covers all types of school from kindergarten to secondary school.

WHAT TIME DID YOU—Leave Home?
Arrive Home?

This should be answered as asked—if, for example, you visited friends after Work or School before going home, give the time you actually arrived home.

For Whom is This Form Being Filled In?

Please remember to mark the appropriate square.

Right Hand Page of Form

For ALL OTHER TRIPS

Other trips are everything except the first trip to Work or School and the trip home after Work or School.

Certain Other Trips are however, not required. See instructions at the top of the right hand page of Form. Station wagons, whether L plates or not, are CARS for the purpose of this Form. IF YOU MADE NO "OTHER TRIPS" MARK THE SQUARE PROVIDED.

WHERE DID YOU GO?

Use one line each time you made a trip of more than about ½ a mile.

The name of a well known building etc., such as Public Hospital, Railway Station and Hagley Park, can be used instead of giving name of District and Street.

HOW DID YOU GO?

For each trip mark in the "TO" column the main means of transport used to get to the place visited and, in the "FROM" column, the main means of transport used in the journey away from the place visited.

D. EVALUATION OF ACCURACY OF TRAVEL AND TRAFFIC SURVEYS AND ADJUSTMENT OF EXPANSION FACTORS

TRANSVERSE SCREEN LINE

The data on motor vehicle trips as reported in the Home Questionnaire, External Cordon Interview, and Taxi and Trade Vehicle Surveys was compared with manual and machine counts taken at the Transverse Screen Line. Over a 20 hour period from 4.30 a.m. to 12.30 a.m. the Travel Surveys were found to have accounted for 72 per cent of passenger cars and 70 per cent of trade vehicles: over the 12 hours from 6.30 a.m. to 6.30 p.m. the Travel Surveys accounted for 75 per cent of passenger cars and 70 per cent of trade vehicles.

EXTERNAL CORDON LINE

A similar check was made by comparing data derived from the Travel Surveys with that gathered at the External Cordon Line. Over a 12 hour period, 6.30 a.m. to 6.30 p.m., the Home Questionnaire and Taxi Surveys accounted for 63 per cent of passenger car trips reported at the External Cordon Line by vehicles domiciled in the Internal Area. The Trade Vehicle Survey accounted for 73 per cent of trade vehicle movements reported at the External Cordon Line by vehicles domiciled in the Internal Area.

INTERNAL CORDON LINE

Bus trips reported in the Home Questionnaire were compared with the number of passengers counted on buses crossing the Internal Cordon Line. Over the 12 hour period, 6 30 a.m. to 6.30 p.m., the Home Questionnaire Survey was found to have accounted

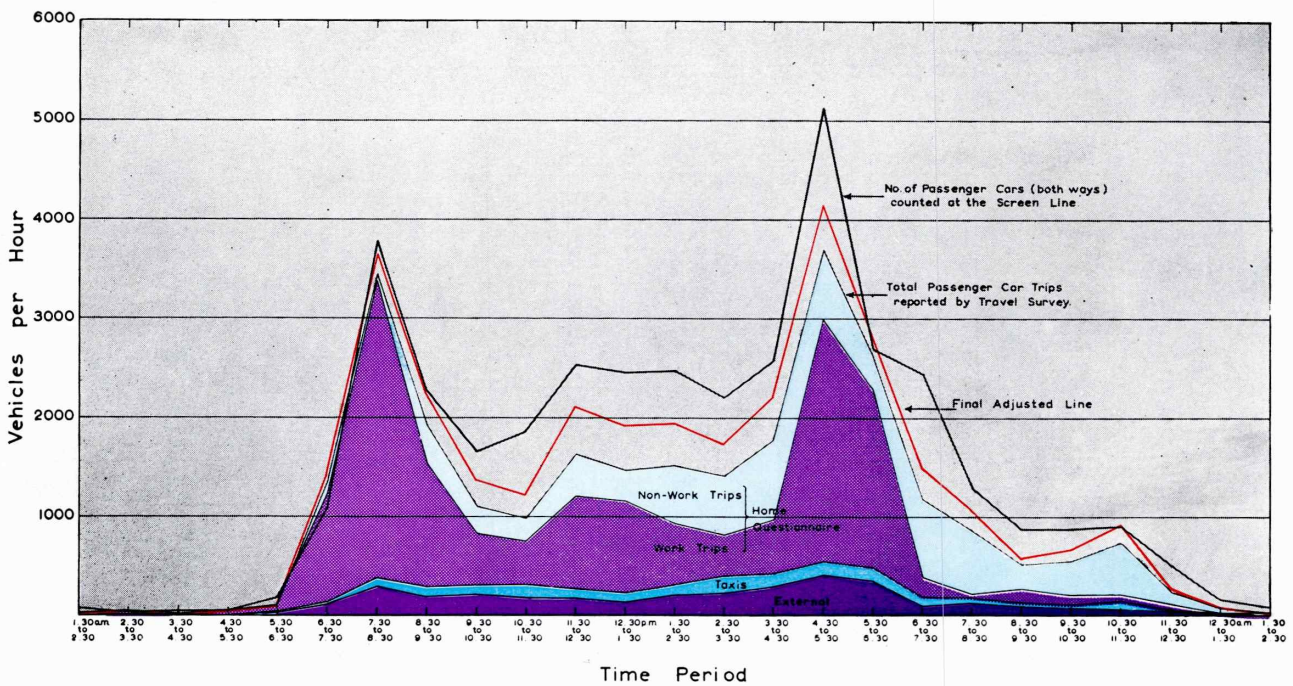


Fig. 72. 1959 SURVEYS: TRANSVERSE SCREEN LINE COMPARISON FOR CARS.

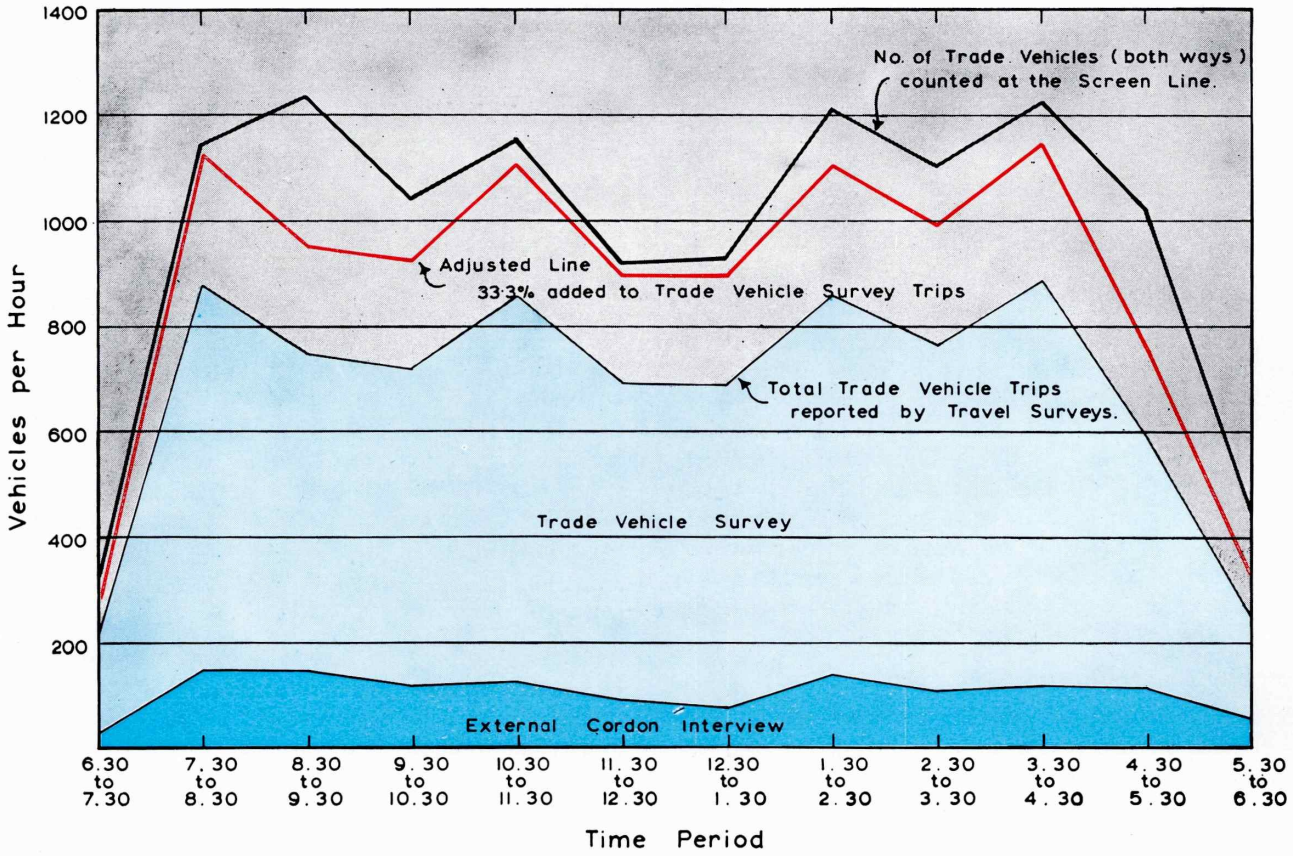


Fig. 73. 1959 SURVEYS: TRANSVERSE SCREEN LINE COMPARISON FOR TRADE VEHICLES.

for 75 per cent of the manual count taken during the same period.

ADJUSTMENT

On the whole the traffic count data was accepted as the more reliable information. Travel Survey data was consequently adjusted upwards—by using suitable factors—in order to bring it into line with the more accurate traffic counts. Travel Survey data was, however, found to be much more accurate for some time periods and for some purposes (Figs. 72 and 73). Therefore a variety of expansion factors were used for selected time periods as follows:

1. *Passenger Cars*

The comparison at the transverse screen line for passenger cars is shown in Figure 72. This diagram shows also the relative importance of different trip purposes and indicates that non-work trips were less well reported than work trips: of note is the greater proportional deficiency in the 9.30 a.m. to 4.30 p.m. period than in the morning and evening peak hours and the exceptionally good reporting in the morning peak. In view of this, the following adjustments were made to trips reported in the Home Questionnaire.

(a) Trips to and from work were increased by five per cent.
(b) All other person trips were increased by 40 per cent.

As the work trips represented by far the greater proportion of trips these adjustments were considered reasonable and were found to be very much in line with some overseas experience. The result was a reasonably good fit between observed and reported travel but left a small overall deficiency for the 12 hour period 6.30 a.m. to 6.30 p.m. (Table 36). This deficiency was considered to represent short distance and 'round-the-block' movements which would have to be borne in mind when making forecasts of future trip volumes.

TABLE 36

PERCENTAGE OF TRANSVERSE SCREEN LINE COUNT OF PASSENGER CARS ACCOUNTED FOR BY TRAVEL SURVEYS 1959: BY TIME PERIOD

TIME PERIOD	PERCENTAGE OF TRANSVERSE SCREEN LINE COUNT ACCOUNTED FOR BY TRAVEL SURVEYS	
	Before Adjustment	*After Adjustment*
4.30 a.m.- 6.30 a.m.	63%	65%
6.30 a.m.- 9.30 a.m.	95%	105%
9.30 a.m.- 4.30 p.m.	63%	80%
4.30 p.m.- 6.30 p.m.	81%	90%
6.30 p.m.-12.30 a.m.	59%	75%
4.30 a.m.-12.30 a.m. (20 hours)	72%	86%
6.30 a.m.- 6.30 p.m. (12 hours)	75%	88%

2. Bus Passengers

The effect of the adjustments described above was to alter results of all modes of travel. By way of example, and to show that the effect was advantageous rather than otherwise, Table 37 gives comparisons at the Internal Cordon Line.

3. *Trade Vehicles*

For trade vehicles a similar situation had to be dealt with and this is illustrated in Figure 73. In this case, adjustments to reported trade vehicle trips were made as follows:

TABLE 37

PERCENTAGE OF INTERNAL CORDON LINE COUNT OF BUS PASSENGERS ACCOUNTED FOR BY TRAVEL SURVEYS 1959: BY TIME PERIOD

TIME PERIOD	PERCENTAGE OF EXTERNAL CORDON LINE CHECK ACCOUNTED FOR BY TRAVEL SURVEYS	
	Before Adjustment	*After Adjustment*
6.30 a.m.- 9.30 a.m.	100%	105%
9.30 a.m.- 4.30 p.m.	75%	105%
4.30 p.m.- 6.30 p.m.	90%	101%
6.30 p.m.-11.30 p.m.	60%	84%
6.30 a.m.-11.30 p.m. (17 hours)	81%	101%
6.30 a.m.- 6.30 p.m. (12 hours)	85%	103%

(a) Heavy trade vehicle trips were increased by 30 per cent.

(b) Light trade vehicle trips were increased by 40 per cent.

The effect of these adjustments is to be seen in Table 38.

METHOD

The adjustments were made by sorting the punched trip data cards and substituting final for provisional expansion factors according to the decisions stated above. All subsequent analysis was done using these final expansion factors.

TABLE 38

PERCENTAGE OF TRANSVERSE SCREEN LINE COUNT AND EXTERNAL CORDON LINE CHECK OF TRADE VEHICLES ACCOUNTED FOR BY TRAVEL SURVEYS 1959: BY TIME PERIOD

TIME PERIOD	PERCENTAGE OF TRANSVERSE SCREEN LINE COUNT ACCOUNTED FOR BY TRAVEL SURVEYS		PERCENTAGE OF EXTERNAL CORDON LINE CHECK ACCOUNTED FOR BY TRAVEL SURVEYS	
	Before Adjustment	*After Adjustment*	*Before Adjustment*	*After Adjustment*
6.30 a.m.- 8.30 a.m. ..	75%	97%	68%	91%
8.30 a.m.-10.30 a.m. ..	64%	82%	69%	92%
10.30 a.m.- 4.30 p.m. ..	73%	94%	83%	101%
4.30 p.m.- 6.30 p.m. ..	57%	73%	50%	67%
6.30 a.m.- 6.30 p.m. .. (12 hours)	70%	89%	73%	97%

EMPLOYMENT CHECK

A check on the effect of the adjustments was made by comparing trips to work in various parts of the study area and an employment survey based on Labour Department record cards. The Travel Surveys were found to account for 91 per cent of the estimated employed population of the area: the percentage became 96 per cent after the five per cent increase in trips to work had been applied. Sickness or leave could well explain the remaining difference but the areal distribution of labour indicated by the Travel Surveys was not such a good fit being significantly in error in certain of the lesser employment areas. This however must be expected in sample surveys.

A particular value of the check was to show up this areal error. This information was useful later to check on the reliability of the trip generation formulae where it was found that, for some subsectors, the formulae gave 1959 predictions significantly different from the reported trip generation. These subsectors were found to be mainly in the areas where employment data showed the poorest correlation.

E. APPLICATION OF THE FRATAR METHOD OF DISTRIBUTING FUTURE TRIP GENERATION AS TRAVEL BETWEEN PARTICULAR SUBSECTORS

THE surveys made in 1959 obtained information as to the trip generation[1] (which we may call t_a, t_b, t_c, etc.) of all the subsectors of the Internal Area (called a, b, c, etc.). The trips or journeys between all pairs of subsectors were also known and these may be called f_{ab}, f_{bc}, f_{ba}, etc. This is illustrated in Figure 74 where it may be seen that f_{ab} represents the journeys between a and b, if the special interest is in subsector a, while f_{ba} is used if the interest is in subsector b. Both symbols in fact represent the same group of journeys.

For 1980 good estimates can be made, for each subsector, of its growth of importance, for example, in residences, commerce and other employment. This growth can be represented by factors α, β, γ, etc., for subsectors a, b, c, etc. Trip generation will increase and may be represented by new values T_a, T_b, T_c, etc. How that trip generation should be distributed as trips (F_{ab}, F_{ba}, F_{bc}, etc., etc.) between particular pairs of subsectors can only be estimated by further calculation. The Fratar method is a logical one which should yield probable results. Since it is one more step in the process of calculating future traffic, and since it involves making further assumptions, it is one more point at which error could enter into the estimates.

[1] The units of measurement are not important to the argument but it may help to think of trip generation and travel in terms of trips per day.

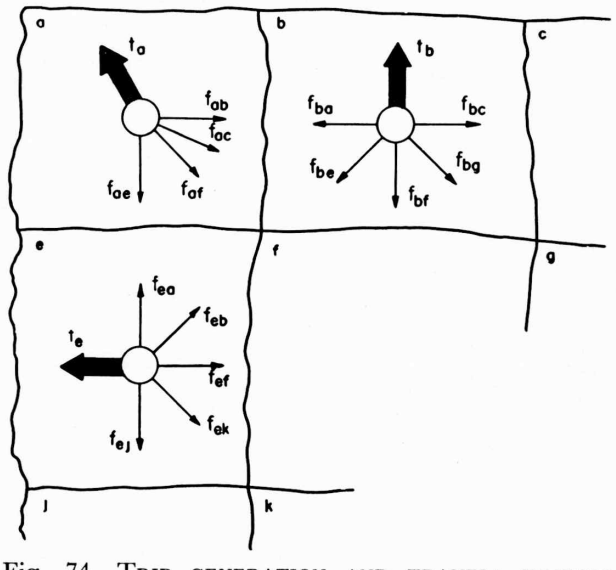


Fig. 74. TRIP GENERATION AND TRAVEL: SYMBOLS USED IN FRATAR METHOD.

Concerning 1959 data:

Obviously $f_{ab} = f_{ba}$
$f_{bc} = f_{cb}$
etc.

and for any subsector (e.g. subsector b):

$t_b = f_{ba} + f_{bc} + f_{bd} + \text{etc.}$

and trip generation may be similarly found for all other subsectors.

For 1980: If subsectors a, b, c, etc., are expected to have growth factors α, β, γ, etc., then future trip generation will be given by:

$$T_a = \alpha \times t_a$$
$$= \alpha (f_{ab} + f_{ac} + f_{ad} + \text{etc.})$$

and similarly $T_b = \beta (f_{ba} + f_{bc} + f_{bd} + \text{etc.})$

It is now necessary to compute values F_{ab}, F_{bc} to suit these predicted values T_a, T_b, etc. Obviously the values computed must satisfy two essential conditions:

(1) $F_{ab} = F_{ba}$
$F_{bc} = F_{cb}$
etc., for all cases—**condition (1)**

(2) Trip generation of a subsector must equal total travel to that subsector, e.g.

$T_a = F_{ab} + F_{ac} + F_{ad} + \text{etc.}$
$T_b = F_{ba} + F_{bc} + F_{bd} + \text{etc.}$
etc., for all cases—**condition (2)**

NEW ASSUMPTIONS

The assumptions made are as follows:

(1) That future travel between any pair of subsectors will be related to the present travel between the same subsectors, so that as a first approximation:

F_{ab} varies as f_{ab}
F_{bc} varies as f_{bc}, etc.

(2) That regarding any particular subsector (say a) as generating travel, then the increased attractiveness of subsectors b, c, and d for travel will vary with their growth factors β, γ, and δ. Thus again as a first approximation:

F_{ab} varies as β
F_{ac} varies as γ etc.

Application of these assumptions leads as a first approximation to the results:

$$F_{ab} = \frac{T_a \times f_{ab} \times \beta}{f_{ab} \times \beta + f_{ac} \times \gamma + f_{ad} \times \delta} \quad \text{and}$$

$$F_{ba} = \frac{T_b \times f_{ab} \times \alpha}{f_{ab} \times \alpha + f_{bc} \times \gamma + f_{bd} \times \delta}$$

These results are unlikely to be the same and will thus fail to satisfy condition (1).

Adjustment of these, by taking their average in each case (e.g. $F'_{ab} = \frac{F_{ab} + F_{ba}}{2}$) will lead to new values for F'_{ab}, F'_{ac}, F'_{ad}, etc. which will fail to satisfy condition (2) and it will be necessary to adjust this by applying new growth factors to all subsectors. These new growth factors α', β', γ', etc. will be such that:

$T_a = \alpha' (F'_{ab} + F'_{ac} + F'_{ad} + \text{etc.})$
$T_b = \beta' (F'_{ba} + F'_{bc} + \text{etc., etc.})$
etc.

By a number of repetitions of this process, travel volumes may be obtained between all pairs of subsectors which will be consistent with conditions (1) and (2) above, and which will reflect to some extent the assumptions made.

This method was derived by T. J. Fratar and has been fully described by him in 'Forecasting Distribution of Interzonal Vehicular Trips By Successive Approximations', *Proceedings Highway Research Board*, Vol. 33, 1954, pp. 376-384.

F. PARKING COSTS AND CAPITAL WORKS REQUIRED

PARKING COSTS, being closely related to total transportation costs, can not be considered simply as the actual costs of land and new construction for car parks. Other costs are involved; the provision of improved parking within a city area will intensify the demand for more adequate access by way of street improvements, new arterials or motorways. Again, adequate parking, by fostering private transport, can lead to substantial losses on public transport operations. In either of these cases extra demands will be made upon the public purse and these demands are really a hidden charge against parking. This is not, of course, the whole story for the private savings of those benefiting from the improvements may exceed the costs (hidden as well as direct) which have been incurred by the public authorities. In fact, if the works are part of an economically conceived scheme, net savings should always result.

Although a true cost cannot easily be assessed, if indeed it can at all, it is helpful to consider the order of the capital cost that may be involved (Table 39). The figures are based on the costs of comparable recent construction in New Zealand, and cannot, of course, be taken as any sort of prediction of what such structures may cost several years hence.

The choice for car parking lies between surface parking, which is expensive in land, and parking in multistorey buildings, which is expensive in construction costs. It must be remembered that such buildings must be designed and built to carry heavy loads and, in New Zealand, to resist earthquake forces. The relative cost of providing places, by surface and by multistorey buildings, is dependent upon the relationship between land and building costs. When the land cost is less than £2 per square foot at 1959 prices, it is not generally economic to erect multistorey buildings unless these can be built for less than about £500 per car place. The estimated costs in Table 40 are based on £2 per square foot as a criterion of land cost and use a realistic range of building construction costs.

If the provision of a mixture of surface and multistorey car parking is taken as costing about £6 million, the average cost per car place will be rather more than £600—about the price of a new small car—and the suggested provision of 500 parking spaces per annum represents an annual expenditure of £300,000 or more per annum on capital works. If, for argument's sake, £600 is taken as the average cost of a parking space, the interest on borrowed money, depreciation and all the costs of managing, supervising, maintaining and servicing of such parks seem likely to amount to about £65 per space per year. Neglecting weekends, and leaving statutory holidays out of the reckoning, the average weekly cost is about 25s. and the average daily cost, 5s. per car space provided. Since 85 per cent utilisation represents saturation of parking, it follows that total charges of 6s. or more per day would have to be levied if such an 'average' parking space is to be paid for by its users. These approximate calculations are not encouraging, and it is apparent that much skill and imagination will have to be used to reduce the construction and operating costs of parking buildings to an absolute minimum. However, it is noteworthy that existing parking lots were already bringing in between 5s. and 7s. per day per space in 1963.

TABLE 39

ESTIMATED CAPITAL COSTS FOR PARKING SPACE:* AT 1959 COSTS

TYPE OF PARKING	LAND COST		BUILDING COST PER CAR SPACE	TOTAL COST PER CAR SPACE
	Square Foot	*Car Space*		
Surface ..	£0.75 to £2	£225 to £600	£25 (say). (This will vary greatly with quality of surface provided)	£225 (if no surfacing required) to £700 for well surfaced car park.
Multi-storey .. (assumed to be 5 storeys)	£2 to £5	£120 to £300	£450 to £700	£570 to £1,000

* Based on a car space of 300 square feet.

TABLE 40

ESTIMATED TOTAL CAPITAL COST TO PROVIDE ADDITIONAL PARKING SPACES FOR 1980: AT 1959 COSTS

TYPE OF PARKING	*To Provide 10,000 Additional Places Required by 1980*	*To Provide 500 Places Needed Annually*
All surface parking	£2.25 million to £6.0 million	£112,500 to £350,000
All in 5 storey garages served by approach ramps	£5.7 million to £10.0 million	£285,000 to £500,000
Mixed parking provision comprising 5,000 places in 5 storey buildings and 5,000 surface places ..	£4.0 million to £8.0 million	£220,000 to £445,000

G. RELATIVE COSTS OF PRIVATE MOTOR CAR AND PUBLIC BUS TRANSPORT IN CHRISTCHURCH: 1961

MILAGE allowances which may be paid to members of Statutory and other Boards in 1961 are contained in Treasury Circular 1960/39. The allowances have been calculated to include depreciation; they are in pence per mile (Table 41).

The adult bus fares of the Christchurch Transport Board for 1961 are given below in pence per section (Table 42).

A section is approximately three quarters of a mile and the basic fare of 3d. is equivalent to a cost of 4d. per mile. Longer journeys—in excess of three sections—are charged at a reduced rate and concession tickets, at about two thirds of normal fares, are used by many regular passengers. The average adult fare is of the order of 3d. per mile. It is relevant to note that the Christchurch Transport Board had a deficit of £164,955 (including £20,228 of loan charges on old Tramway Loan) in its annual accounts for the year ending March 31st, 1962.

TABLE 42

ADULT BUS FARES, 1961

Number of Sections	*Fare*
1	3d.
2	6d.
3	9d.
4	10d.
5	11d.
6	1/-
7	1/1
8	1/2
9	1/3
10	1/4
11 and 12	1/6
13 and 14	1/8

TABLE 41

MILAGE ALLOWANCES, 1961

PER ANNUM	CAPACITY OF ENGINE		
	Less than 1001 c.c.	*1001-2000 c.c.*	*Over 2000 c.c.*
Up to 2,000 miles ..	8.5d.	10.0d.	11.25d.
Over 2,000 miles ..	7.0d.	8.25d.	9.25d.

TABLE 43

GENERALISED LAND USE[1] OF THE INTERNAL AREA, 1956: BY SUBSECTORS

SUBSECTOR	AREA OF SUBSECTOR (ACRES)			PERCENTAGE OF AREA OF SUBSECTOR (WITHIN THE URBAN FENCE) BY LAND USE								
	Total	*Outside Urban Fence*	*Inside Urban Fence*	*Residential*	*Commercial*	*Industrial*[2]	*Public Buildings*	*Open Space*	*Streets and Drains*	*Developed*[3]	*Un-developed*[3]	*Total Area*
11	482	—	482	41.0	2.0	24.8	4.0	—	20.9	92.7	7.3	100
12	496	—	496	38.9	0.2	14.0	4.4	4.0	19.3	80.6	19.4	100
13	605	—	605	35.0	0.6	2.6	2.3	0.1	26.4	67.0	33.0	100
14	1,456	—	1,456	14.1	0.3	6.3	1.8	5.6	6.2	34.3	65.7	100
15	1,890	240	1,650	10.8	0.3	1.6	3.4	9.2	24.7	50.0	50.0	100
16	2,476	826	1,650	13.5	0.3	13.1	0.6	0.8	12.1	40.4	59.6	100
21	360	—	360	61.8	0.1	2.8	2.1	4.4	26.9	98.1	1.9	100
22	445	—	445	62.4	—	1.6	8.7	3.7	20.3	96.7	3.3	100
23	456	—	456	62.7	0.2	0.8	6.7	2.9	10.2	83.5	16.5	100
24	382	—	382	59.4	0.3	0.3	7.1	0.4	13.9	81.4	18.6	100
25	2,515	1,215	1,300	11.0	—	3.9	2.2	0.2	11.2	28.5	71.5	100
26	550	—	550	25.8	0.1	0.3	1.3	2.1	9.7	39.3	60.7	100
31	246	—	246	70.7	0.8	0.7	4.9	2.1	18.2	97.4	2.6	100
32	236	—	236	69.3	0.9	2.0	3.4	—	22.0	97.6	2.4	100
33	323	—	323	60.5	1.1	2.0	13.5	5.7	14.0	96.8	3.2	100
34	292	—	292	63.6	0.2	1.1	2.3	9.6	20.2	97.0	3.0	100
35	337	—	337	57.4	1.3	5.5	3.8	0.5	30.0	98.5	1.5	100
36	794	374	420	45.3	0.5	3.4	6.5	1.4	19.5	76.6	23.4	100
37	810	—	810	27.2	0.1	0.4	2.8	1.2	2.5	34.2	65.8	100
38	1,222	—	1,222	17.5	0.1	4.7	1.7	—	8.3	32.3	67.7	100
41	256	—	256	67.5	0.6	1.6	2.4	2.0	22.5	96.6	3.4	100
42	347	—	347	51.4	0.1	1.1	10.1	1.5	33.7	97.9	2.1	100
43	475	—	475	39.4	0.1	0.8	2.0	2.9	30.9	76.1	23.9	100
44	322	—	322	52.1	0.3	0.6	2.9	3.5	27.2	86.6	13.4	100
45	693	326	367	43.6	0.3	1.1	3.7	4.4	16.0	69.1	30.9	100
46	1,462	640	822	24.4	0.1	0.3	1.9	0.4	30.6	57.7	42.3	100
51	222	—	222	68.8	1.4	3.7	3.2	2.0	19.7	98.8	1.2	100
52	344	—	344	59.9	0.5	1.1	4.9	4.8	22.8	94.0	6.0	100
53	297	—	297	57.0	0.7	2.7	4.4	7.7	24.5	97.0	3.0	100
54	432	—	432	42.6	0.1	0.2	4.8	5.5	23.1	76.3	23.7	100
55	2,613	1,913	700	26.4	0.1	1.1	0.8	—	7.1	35.5	64.5	100
56	1,085	164	921	23.0	0.1	2.3	—	8.2	13.8	47.4	52.6	100
57	559	167	392	41.0	1.6	1.1	1.9	0.4	34.6	80.6	19.4	100
58	794	—	794	23.1	0.3	0.7	0.9	20.1	10.0	55.1	44.9	100
59	770	107	663	27.7	0.3	0.4	3.7	11.1	17.6	60.7	39.3	100

61	254	—	254	59.1	1.0	8.9	3.8	5.7	17.7	96.2	3.8	100
62	323	—	323	61.0	0.6	9.7	3.6	4.8	13.2	92.9	7.1	100
63	408	—	408	40.0	0.2	3.8	1.4	7.5	18.9	71.8	28.2	100
64F[4]	1,488	1,228	260	42.9	0.6	4.3	5.4	0.5	9.8	63.5	36.5	100
64H[4]	1,050	714	336	19.3	—	4.5	1.8	3.6	3.0	32.2	67.8	100
65F[4]	105	—	105	46.1	0.2	0.9	3.2	6.9	29.4	86.7	13.3	100
65H[4]	1,877	872	1,005	21.0	—	0.1	0.8	0.1	3.1	25.1	74.9	100
66F[4]	375	121	254	45.0	1.3	1.4	10.7	2.2	33.6	94.2	5.8	100
66H[4]	757	525	232	16.7	0.1	—	0.1	3.4	14.5	34.8	65.2	100
71	343	—	343	52.4	1.7	12.8	1.6	2.8	18.6	89.9	10.1	100
72	441	—	441	50.1	0.1	2.4	2.4	3.2	21.6	79.8	20.2	100
73F[4]	928	349	579	21.3	0.4	14.2	1.1	2.3	21.1	60.4	39.6	100
73H[4]	618	336	282	34.3	0.4	2.1	3.6	0.8	12.5	53.7	46.3	100
81	276	—	276	43.1	3.2	15.8	5.3	4.9	24.9	97.2	2.8	100
82	267	—	267	63.1	0.4	2.2	4.0	6.4	19.9	96.0	4.0	100
83	285	—	285	61.5	—	0.7	9.2	5.1	18.0	94.5	5.5	100
84	241	—	241	65.0	0.9	4.6	0.9	—	23.7	95.1	4.9	100
85	949	285	664	31.8	0.1	1.9	7.8	3.1	6.8	51.5	48.5	100
86	362	—	362	60.7	0.5	0.6	4.8	4.0	17.9	88.5	11.5	100
87F[4]	109	—	109	37.6	0.9	0.2	0.1	—	17.7	56.5	43.5	100
87H[4]	1,286	450	836	32.5	—	1.1	9.7	0.7	10.9	54.9	45.1	100
91	469	—	469	40.0	1.0	6.7	2.1	31.1	14.3	95.2	4.8	100
92	328	—	328	59.5	0.4	0.2	2.5	0.4	17.5	80.5	19.5	100
93	1,428	572	856	21.7	0.1	0.3	1.3	2.0	27.4	52.8	47.2	100
01	482	—	482	23.5	18.1	10.0	9.7	5.1	33.2	99.6	0.4	100
02	149	—	149	53.4	1.3	8.1	9.9	0.7	24.8	98.2	1.8	100
03	230	—	230	40.8	2.4	16.2	10.3	0.5	27.0	97.2	2.8	100
04	270	—	270	20.6	7.8	36.4	5.8	—	26.9	97.5	2.5	100
05	522	—	522	0.1	—	—	6.1	84.1	9.7	100.0	—	100
TOTAL	44,353[5]	11,424	32,929[5]	32.5	0.7	4.1	3.4	5.1	18.9	64.7	35.3	100

[1] The land use percentages are calculated from a survey made in 1956 and the following procedure was used in computing the percentages, for each subsector, of the various types of land use.

(i) The acreage for *Undeveloped Land* was used as a base and was expressed as a percentage of the total area of the subsector.
(ii) The balance (100% less the percentage of *Undeveloped Land*) was taken as the percentage of the subsector in *Developed Land*.
(iii) The acreages for *Residential*, *Commercial*, *Industrial* (including Railways), *Public Buildings*, and *Open Space* were each expressed as a percentage of the total subsector area. These were then summed.
(iv) The difference between the percentage of *Developed Land* and that obtained in (iii) was assumed to be in *Streets and Drains*, a land use category for which no measured areas were available.

[2] Includes railway land.
[3] Developed land is used for urban purposes; undeveloped land is used for non-urban purposes.
[4] For these subsectors the distinction is between the flat (F) and hill (H) portions.
[5] Includes 689 acres of land inside the urban fence but outside the Internal Area. All the 689 acres are assumed to be in *Streets and Drains*.

TABLE 44

RESIDENTS, HOUSEHOLDS, VALUATION, EMPLOYMENT, CARS, AND DISTANCE, FOR THE INTERNAL AREA, 1959: BY SUBSECTORS

SUBSECTOR	PERSONS RESIDENT[1]	HOUSEHOLDS[2]		AVERAGE VALUATION OF RESIDENTIAL IMPROVEMENTS (IN £)	EMPLOYED POPULATION[3]			CARS PER HOUSEHOLD	DISTANCE FROM CATHEDRAL SQUARE[4] (MILES)
		Number	*Average Size (Persons)*		*Total*	*Industrial*	*Commercial*		
11	2,807	1,010	2.78	1,859	3,007	2,099	195	0.74	1.6
12	3,326	967	3.36	2,075	347	191	33	0.73	2.3
13	4,257	988	4.20	2,460	471	181	89	0.89	3.1
14	3,700	1,043	3.47	2,236	1,286	1,056	—	0.94	3.9
15	3,905	1,044	3.74	2,198	223	102	12	0.74	5.6
16	4,080	985	3.84	2,067	2,254	1,463	54	0.75	5.0
21	2,927	1,011	2.72	2,650	198	75	14	0.78	1.4
22	3,155	912	3.40	2,807	189	14	15	1.09	1.9
23	3,527	1,028	3.43	2,754	154	31	31	1.12	2.4
24	3,568	1,037	3.42	2,299	245	46	24	1.02	2.5
25	4,272	1,083	3.59	2,575	928	668	4	1.02	3.7
26	3,879	995	3.90	2,508	94	7	30	0.70	3.1
31	3,124	974	2.90	2,007	213	31	48	0.84	1.1
32	2,589	994	2.52	1,710	260	105	25	0.63	1.0
33	3,405	986	3.18	2,428	477	27	95	1.06	1.7
34	3,240	1,022	3.17	1,814	127	26	41	0.86	1.6
35	3,504	970	3.56	2,305	498	190	172	0.96	2.4
36	2,793	938	2.98	2,350	528	223	47	0.74	2.4
37	3,651	950	3.76	2,180	144	35	—	0.87	3.2
38	4,340	1,019	4.00	2,099	543	429	14	0.68	3.6
41	3,450	954	3.59	1,448	251	76	81	0.70	1.1
42	2,926	987	2.87	1,977	259	42	7	0.94	1.5
43	3,830	882	4.31	2,123	162	59	19	1.02	2.3
44	3,519	1,005	3.50	1,921	172	58	41	0.71	1.9
45	4,342	1,043	4.15	2,325	166	20	13	0.90	2.3
46	4,187	1,008	4.10	2,011	186	64	6	0.56	2.8
51	3,179	893	3.46	1,443	485	208	46	0.64	1.0
52	3,297	1,008	3.27	1,790	172	58	37	0.75	1.6
53	3,013	929	3.24	1,454	369	80	53	0.73	1.6
54	3,470	960	3.61	1,935	71	14	—	0.80	2.2
55	2,567	776	3.31	1,530	169	88	10	0.90	4.7
56	4,047	1,009	3.89	1,972	387	288	9	0.85	3.1
57	3,500	960	3.65	1,405	552	145	243	0.71	4.7
58	3,655	969	3.77	1,573	162	66	39	0.69	4.5
59	3,611	989	3.64	1,367	264	62	16	0.83	4.7
61	2,764	914	2.98	1,107	857	498	71	0.80	1.2
62	3,231	955	3.35	1,475	651	362	53	0.73	1.7
63	3,528	904	3.90	1,671	417	275	—	0.67	2.3

64	3,100	919	3.37	1,911	607	468	30	0.91	3.4
65	3,120	820	3.80	2,117	111	17	13	1.12	5.1
66	2,924	878	3.33	1,833	279	90	102	0.88	7.0
71	2,913	898	3.24	1,203	1,331	870	25	0.51	1.3
72	3,183	927	3.43	2,158	112	34	43	0.95	2.1
73	3,158	883	3.50	2,620	1,496	1,348	—	0.81	2.6
81	3,009	774	3.69	884	2,946	2,074	250	0.58	0.9
82	2,994	946	3.16	1,481	278	84	52	0.81	1.5
83	3,556	977	3.64	1,714	98	23	6	0.81	1.7
84	3,207	961	3.34	1,340	294	127	73	0.38	1.5
85	3,387	919	3.69	2,139	146	14	6	0.93	2.6
86	3,452	1,018	3.39	1,939	162	23	46	0.86	2.1
87	3,640	955	3.63	2,988	247	19	—	0.94	2.7
91	3,534	1,008	3.38	1,466	1,131	604	107	0.76	1.5
92	3,791	949	3.99	1,840	75	9	5	0.80	2.1
93	3,975	960	4.04	1,960	531	103	18	1.06	2.7
01	4,348	1,244	2.54	2,423	29,273	6,883	15,567	0.43	0.0
02	2,576	766	3.00	1,718	831	374	238	0.62	0.5
03	1,999	654	2.85	1,228	1,720	838	336	0.54	0.5
04	1,513	355	3.28	1,071	8,521	5,413	1,657	0.50	0.5
05	591	—	—	—	1,438	3	46	—	0.6
INTERNAL AREA	196,135	54,912	3.46	1,957	69,565	28,880	20,307	0.81	—

[1] Includes households and other residential places.
[2] A household unit is defined as a group of rooms or a single room, occupied or intended for occupancy as separate living quarters, by a family or other group of persons living together or by a person living alone.
[3] Persons employed in the subsector. Excludes one man (working-proprietor) businesses.
[4] Distance from centre of Central Traffic District (subsector 01) to assumed traffic centroid of subsector.

TABLE 45

POPULATION GROWTH FOR NEW ZEALAND, SOUTH ISLAND, CANTERBURY PROVINCE, AND CHRISTCHURCH URBAN AREA[1]: 1901-1956

CENSUS YEAR	NEW ZEALAND (including overseas forces)		SOUTH ISLAND		CANTERBURY PROVINCE		CHRISTCHURCH URBAN AREA[2]	
	Excluding Maoris	*Including Maoris*	*Excluding Maoris*	*Including Maoris*	*Excluding Maoris*	*Including Maoris*	*Excluding Maoris*	*Including Maoris*
1901	770,312	815,853	382,140	384,380	143,248	144,195	Not available	Not available
1906	886,000	936,304	411,841	414,399	159,303	160,263	Not available	Not available
1911	1,005,589	1,058,308	444,735	447,698	173,443	174,513	87,565	Not available
1916	1,096,228	1,149,225	448,377	450,229	181,869	182,729	93,488	Not available
1921	1,214,677	1,271,664	477,658	479,746	199,034	199,969	106,111	Not available
1926	1,344,469	1,408,139	512,656	515,460	213,890	215,079	118,564	118,708
1936	1,491,484	1,573,810	552,545	555,774	232,992	234,399	133,233	133,515
1945	1,647,635	1,747,679	552,570	556,006	245,347	246,848	150,580	151,068
1951	1,825,626	1,941,366	621,439	625,603	278,346	280,024	173,657	174,221
1956	2,038,883	2,176,224	671,441	676,698	305,464	307,513	192,516	193,367

[1] Source: *Population Census of New Zealand* (for Census years), Wellington.

[2] Urban Areas in New Zealand were formed in 1917 and a revision was made in 1951. Revised figures, exclusive of Maoris, were prepared for each census from 1911; revised figures inclusive of Maoris were prepared only from 1926.

TABLE 46

POPULATION 1959 AND 1980: BY AREA AND GROWTH FACTOR

AREA	POPULATION		GROWTH FACTOR
	1959	*1980*	
I AREA A			
1. Rangiora/Loburn	5,326	8,500	1.596
2. Woodend	1,060	2,000	1.887
3. Tuahiwi	371	750	2.022
4. Kaiapoi/Pines	3,850	8,000	2.078
5. Chaneys/Kainga/Stewarts Gully ..	1,096	1,500	1.369
6. Marshland/Spencer Park/Brooklands ..	1,415	2,750	1.943
7. Burwood	261	300	1.149
8. Belfast	1,685	3,250	1.929
9. Harewood	422	1,000	2.370
10. Yaldhurst	251	500	1.992
11. Templeton	644	1,000	1.553
12. Prebbleton	561	1,000	1.783
13. Halswell	1,510	5,000	3.311
SUBTOTAL ..	18,452	35,550[5]	1.927
14. Internal Area	196,135[1]	311,450[4]	1.588
AREA A TOTAL ..	214,587[2]	347,000[3]	1.617
II LYTTELTON (Pt. Area B)	3,379	3,650	1.080
III AREA B (Minus Lyttelton) being remainder of Canterbury Province	106,621	129,350[6]	1.213
IV AREA C (Remainder South Island) ..	380,000	500,000[6]	1.316
V TOTAL SOUTH ISLAND .. .. .. (I + II + III + IV)	704,587	980,000[7]	1.391

[1] Population of the Internal Area of 196,135 is derived from 1959 travel survey (Home Questionnaire).
[2] Total 214, 587 is 1959 travel survey total of Internal Area plus 1-13 inclusive of Area A.
[3] Total 347,000 taken from graph for Area A in Figure 42.
[4] Internal Area 311,450 is total for Area A minus items 1-13 inclusive.
[5] Items 1 to 13 of Area A for 1980 are based on graph for Area A in Figure 42, together with areas and densities within urban fence and some special studies.
[6] Taken from graph in Figure 42.
[7] Taken from graph in Figure 42: 1980 South Island total is 25 per cent of New Zealand's estimated population in 1980.

TABLE 47

LIVING AREA, DENSITY, AND NUMBER OF HOUSEHOLDS IN THE INTERNAL AREA, 1959 AND 1980: BY SUBSECTORS

SUBSECTOR	LIVING AREA[1] IN ACRES		HOUSEHOLDS[2] PER ACRE OF LIVING AREA		NUMBER OF HOUSEHOLDS[2]	
	1959	*1980*	*1959*	*1980*	*1959*	*1980*
11	267	269	3.8	4.0	1,010	1,076
12	298	355	3.2	3.4	967	1,207
13	325	401	3.0	3.4	988	1,363
14	388	1,168	2.7	3.4	1,043	3,971
15	287	815	3.6	3.4	1,044	2,771
16	314	775	3.1	3.4	985	2,635
21	344	344	2.9	3.5	1,011	1,204
22	377	395	2.4	2.7	912	1,067
23	392	439	2.6	2.7	1,028	1,185
24	314	372	3.3	3.4	1,037	1,265
25	288	1,047	3.8	3.4	1,083	3,560
26	297	552	3.3	3.4	995	1,877
31	235	235	4.2	4.0	974	940
32	227	226	4.4	4.0	994	904
33	283	283	3.5	3.4	986	962
34	279	279	3.7	3.4	1,022	949
35	303	303	3.2	3.4	970	1,030
36	[3]	309	—	3.4	938	1,051
37	304	806	3.1	3.4	950	2,740
38	349	1,010	2.9	3.4	1,019	3,434
41	245	245	3.9	4.0	954	980
42	283	283	3.5	3.4	987	962
43	[3]	454	—	3.4	882	1,544
44	279	310	3.6	3.4	1,005	1,054
45	[3]	359	—	3.4	1,043	1,221
46	[3]	740	—	3.4	1,008	2,516
51	205	197	4.4	4.0	893	788
52	[3]	319	—	3.4	1,008	1,085
53	273	293	3.4	3.4	929	996
54	276	376	3.5	3.4	960	1,278
55	[3]	498	—	3.4	776	1,693
56	[3]	692	—	3.4	1,009	2,353
57	258	367	3.7	3.4	960	1,248
58	318	608	3.0	3.4	969	2,067
59	280	796	3.5	3.4	989	2,706
61	232	203	3.9	4.0	914	812
62	257	277	3.7	3.4	955	942
63	[3]	379	—	3.4	904	1,289
64	[3]	617	3.3[4]	3.0	919	1,851
65	[3]	1,080	2.8[4]	2.6	820	2,808
66	[3]	465	3.3[4]	3.0	878	1,395

TABLE 47—*continued*

SUBSECTOR	LIVING AREA[1] IN ACRES		HOUSEHOLDS[2] PER ACRE OF LIVING AREA		NUMBER OF HOUSEHOLDS[2]	
	1959	*1980*	*1959*	*1980*	*1959*	*1980*
71	247	261	3.6	3.6	898	940
72	310	397	3.0	3.4	927	1,350
73	([3])	486	3.3[4]	3.0	883	1,458
81	223	164	3.5	4.0	774	656
82	245	245	3.9	4.0	946	980
83	260	260	3.8	4.0	977	1,040
84	230	230	4.2	4.0	961	920
85	([3])	597	—	3.4	919	2,030
86	314	356	3.2	3.4	1,018	1,210
87	([3])	789	2.6[4]	2.6	955	2,051
91	255	240	4.0	4.0	1,008	960
92	264	313	3.6	3.4	949	1,064
93	([3])	836	—	3.4	960	2,842
Sector 0	1,582[5]	1,582[5]	—	—	3,019	3,000
TOTAL	—	—	—	—	54,912	87,280

[1] Living Area is defined as containing all those uses normally found in residential areas including those that are required to satisfy the everyday needs of the residential population, such as primary schools, small parks, churches and local shops. Excluded from the definition are 'non-living' uses which have a wider regional significance or are shared by more than one part of the urban area, for example an industrial district, secondary school, hospital, racecourse, golf course, airport and cemetery.

The 1980 figures represent the capacity of each subsector when it is fully built upon for urban purposes (see Chapter Four).

[2] A household unit is defined as a group of rooms or a single room, occupied or intended for occupancy as separate living quarters, by a family or other group of persons living together or by a person living alone. See Chapter Four for the method of forecasting 1980 households.

[3] No Living Area measured because special conditions, for example hill subsector or extreme mix of uses, make it very difficult to define Living Area.

[4] Includes hill development and figure obtained by special study.

[5] Total area of land (not Living Area) within Sector.

TABLE 48

EMPLOYMENT IN THE INTERNAL AREA, 1959[1] AND 1980[2]: BY SUBSECTORS

SUBSECTOR	TOTAL EMPLOYMENT		EMPLOYMENT IN INDUSTRY		COMMERCIAL EMPLOYMENT IN SHOPPING CENTRES[3]		OTHER EMPLOYMENT	
	1959	*1980*	*1959*	*1980*	*1959*	*1980*	*1959*	*1980*
11	3,007	4,020	2,099	2,664	195	250	713	1,106
12	347	594	191	352	33	65	123	177
13	471	2,388	181	168	89	283	201	1,937
14	1,286	2,262	1,056	1,731	—	109	230	422
15	223	2,221	102	1,975	12	60	109	186
16	2,254	6,310	1,463	5,172	54	360	737	778
21	198	222	75	54	14	16	109	152
22	189	250	14	—	15	22	160	228
23	154	199	31	27	31	55	92	117
24	245	378	46	27	24	27	175	324
25	928	2,320	668	871	4	160	256	1,289
26	94	565	7	460	30	38	57	67
31	213	265	31	27	48	55	134	183
32	260	278	105	54	25	33	130	191
33	477	644	27	27	95	100	355	517
34	127	141	26	27	41	33	60	81
35	498	605	190	151	172	227	136	227
36	528	564	223	151	47	55	258	358
37	144	1,128	35	487	—	383	109	258
38	543	1,730	429	1,466	14	44	100	220
41	251	328	76	54	81	127	94	147
42	259	340	42	27	7	11	210	302
43	162	199	59	27	19	33	84	139
44	172	180	58	27	41	44	73	109
45	166	240	20	—	13	16	133	224
46	186	270	64	54	6	33	116	183
51	485	965	208	557	46	49	231	359
52	172	177	58	54	37	38	77	85
53	369	510	80	54	53	100	236	356
54	71	126	14	—	—	11	57	115
55	169	2,030	88	1,899	10	33	71	98
56	387	974	288	725	9	33	90	216
57	552	754	145	103	243	383	164	268
58	162	215	66	54	39	44	57	117
59	264	395	62	54	16	49	186	292
61	857	2,275	498	1,796	71	82	288	397
62	651	712	362	308	53	60	236	344
63	417	469	275	254	—	—	142	215
64	607	530	468	303	30	55	109	172
65	111	194	17	—	13	33	81	161
66	279	315	90	—	102	194	87	121

TABLE 48—*continued*

SUBSECTOR	TOTAL EMPLOYMENT		EMPLOYMENT IN INDUSTRY		COMMERCIAL EMPLOYMENT IN SHOPPING CENTRES[3]		OTHER EMPLOYMENT	
	1959	*1980*	*1959*	*1980*	*1959*	*1980*	*1959*	*1980*
71	1,331	2,378	870	1,677	25	33	436	668
72	112	92	34	—	43	49	35	43
73	1,496	3,960	1,348	3,722	—	22	148	216
81	2,946	5,080	2,074	3,846	250	300	622	934
82	278	631	84	368	52	55	142	208
83	98	125	23	27	6	11	69	87
84	294	352	127	108	73	92	94	152
85	146	238	14	—	6	33	126	205
86	162	206	23	—	46	68	93	138
87	247	383	19	—	—	5	228	378
91	1,131	1,720	604	930	107	122	420	668
92	75	103	9	—	5	11	61	92
93	531	839	103	81	18	60	410	698
Subtotal	27,782	55,389	15,369	33,000	2,463	4,664	9,950	17,725
01	29,273	40,900	6,883	6,120	15,567	24,400	6,823	10,380
02	831	1,189	374	285	238	108	219	796
03	1,720	2,820	838	1,140	336	322	546	1,358
04	8,521	12,005	5,413	7,355	1,657	1,025	1,451	3,625
05	1,438	1,697	3	100	46	—	1,389	1,597
Subtotal	41,783	58,611	13,511	15,000	17,844	25,855	10,428	17,756
TOTAL	69,565	114,000	28,880	48,000	20,307	30,519	20,378	35,481

[1] Source: Labour Department records which exclude one man (working-proprietor) businesses.
[2] See Chapter Four for method of forecast.
[3] Includes Hotels: for inclusion as a shopping centre there must be at least six shops.

TABLE 49

MOTOR VEHICLES AND PERSONS PER VEHICLE IN CHRISTCHURCH[1]: 1935-1980

YEAR	POPULATION[2]	NUMBER OF VEHICLES[3] BY CLASS				NUMBER OF PERSONS PER VEHICLE BY CLASS			
		Total	*Cars*	*Trade Vehicles*	*Remainder*	*All Classes*	*Car*	*Trade Vehicle*	*Remainder*
1935	135,000	18,162	12,865	2,522	2,775	7.44	10.49	53.53	48.65
1937	139,000	22,408	16,568	2,974	2,866	6.20	8.39	46.74	48.50
1939	142,000	25,533	19,966	3,026	2,541	5.56	7.11	46.93	55.88
1941	148,000	25,505	19,198	2,726	3,581	5.80	7.71	54.29	41.33
1943	151,000	23,748	18,921	2,803	2,024	6.37	7.98	53.87	74.60
1945	155,562	25,209	19,340	3,083	2,786	6.16	8.04	50.46	55.84
1947	163,000	27,723	20,640	3,715	3,368	5.89	7.90	43.88	48.40
1949	172,000	30,907	22,732	4,284	3,891	5.57	7.57	40.15	44.20
1950	176,000	33,097	24,441	4,582	4,074	5.32	7.20	38.41	43.20
1951	179,143	36,944	26,709	5,156	5,079	4.85	6.71	34.74	35.27
1952	184,000	40,907	29,848	5,658	5,401	4.50	6.18	32.52	34.07
1953	188,000	42,031	30,876	5,757	5,398	4.47	6.10	32.65	34.83
1954	192,000	46,008	34,201	6,230	5,577	4.18	5.62	30.82	34.43
1955	196,000	49,930	37,026	6,775	6,129	3.93	5.30	28.93	31.98
1956	199,388	55,263	41,777	7,406	6,080	3.61	4.77	26.92	32.79
1957	205,000	58,787	45,525	7,163	6,099	3.49	4.50	28.62	33.61
1958	211,000	61,094	47,608	7,450	6,036	3.45	4.432	28.32	34.96
1959	217,330	66,723	53,117	7,969	5,637	3.257	4.066	27.10	38.55
1960	221,000	70,439	55,524	8,466	6,449	3.140	3.980	26.10	34.27
1961	226,884	75,000	59,000	9,370	6,630	3.013	3.830	24.11	34.08
1966	250,000	96,000	77,000	11,400	7,600	2.604	3.246	21.92	32.89
1971	275,000	116,000	94,000	13,000	9,000	2.370	2.925	21.15	30.55
1976	300,000	136,000	112,000	14,700	9,300	2.206	2.678	20.40	32.25
1980	330,800	152,500	125,620	16,150	10,730	2.169	2.633	20.47	30.82

[1] Defined as Christchurch City; Riccarton and Lyttelton Boroughs; Halswell, Heathcote, Paparua and Waimairi Counties.
[2] Population figures for 1945, 1951, 1956 and 1961 are Census figures; those for 1958, 1959 and 1960 are annual estimates of the Department of Statistics; other figures for 1935-1961 are taken off graph plotted on Census figures. The figures for 1966-1980 are obtained by methods discussed in Chapter Four.
[3] Vehicle figures for 1935-1960 are from registrations at Post Offices in Christchurch; those for 1961-1980 are obtained by methods discussed in Chapter Four.

TABLE 50

SUBSECTOR CHARACTERISTICS USED IN FORMULAE: 1959 AND 1980 VALUES

SUBSECTOR		1959				1980			
	D	*H*	*V*	*E*	*S*	*H*	*V*	*E*	*S*
11	1.6	1010	1859	3007	195	1076	1860	4020	250
12	2.3	967	2075	347	33	1207	2080	594	40
13	3.1	988	2460	471	68	1363	2460	2388	258
14	3.9	1043	2236	1286	0	3971	2240	2262	109
15	5.6	1044	2198	223	12	2771	2060	2221	60
16	5.0	985	2067	2254	54	2635	2060	6310	335
21	1.4	1011	2650	198	14	1204	2650	222	16
22	1.9	912	2807	189	15	1067	2800	250	22
23	2.4	1028	2754	154	31	1185	2750	199	55
24	2.5	1037	2299	245	24	1265	2300	378	27
25	3.7	1083	2575	928	4	3560	2600	2320	130
26	3.1	995	2508	94	30	1877	2500	565	38
31	1.1	974	2007	213	25	940	2010	265	30
32	1.0	994	1710	260	25	904	1710	278	33
33	1.7	986	2428	477	95	962	2420	644	100
34	1.6	1022	1814	127	41	949	1820	141	33
35	2.4	970	2305	498	154	1030	2310	605	200
36	2.4	938	2350	528	47	1051	2350	564	55
37	3.2	950	2180	144	0	2740	2180	1128	383
38	3.6	1019	2099	543	14	3434	2100	1730	44
41	1.1	954	1448	251	58	980	1500	328	100
42	1.5	987	1997	259	7	962	1980	340	11
43	2.3	882	2123	162	19	1544	2120	199	33
44	1.9	1005	1921	172	41	1054	1950	180	44
45	2.3	1043	2325	166	13	1221	2150	240	16
46	2.8	1008	2011	186	6	2516	2060	270	33
51	1.0	893	1443	485	46	788	1400	965	49
52	1.6	1008	1790	172	37	1085	1790	177	38
53	1.6	929	1454	369	53	996	1500	510	100
54	2.2	960	1935	71	0	1278	2000	126	11
55	4.7	776	1530	169	10	1693	1600	2030	33
56	3.1	1009	1972	387	9	2353	2060	974	33
57	4.7	960	1405	552	214	1248	1500	754	350
58	4.5	969	1573	162	39	2067	1680	215	44
59	4.7	989	1367	264	16	2706	1680	395	49
61	1.2	914	1107	857	56	812	1150	2275	62
62	1.7	955	1475	651	53	942	1500	712	60
63	2.3	904	1671	417	0	1289	1700	469	0
64	3.4	919	1911	607	30	1851	2060	530	55
65	5.1	820	2117	111	13	2808	2120	194	33
66	7.0	878	1833	279	77	1395	2000	315	164
71	1.3	898	1203	1331	25	940	1220	2378	33
72	2.1	927	2158	112	43	1350	2160	92	49
73	2.6	883	2620	1496	0	1458	2750	3960	22
81	0.9	774	884	2946	250	656	950	5080	300
82	1.5	946	1481	278	52	980	1500	631	55
83	1.7	977	1714	98	6	1040	1710	125	11
84	1.5	961	1340	294	53	920	1340	352	67
85	2.6	919	2139	146	6	2030	2140	238	33
86	2.1	1018	1939	162	46	1210	2000	206	68
87	2.7	955	2988	247	0	2051	2900	383	5
91	1.5	1008	1466	1131	89	960	1470	1720	100
92	2.1	949	1840	75	5	1064	1840	103	11
93	2.7	960	1960	531	18	2842	2060	839	60
01	0.0	1244	*	29723	15567		*	40900	24400
02	0.5	766	1718	831	238		1900	1189	108
03	0.5	654	1228	1720	336	3000[1]	1400	2820	322
04	0.5	355	1071	8521	1657		1000	12005	1025
05	0.6	*	*	1438	46		*	1697	0

D: Distance of assumed traffic centroid from centre of city (Cathedral Square).
V: Average valuation of residential improvements.
S: Commercial employment (excluding hotels), in defined shopping centres. In subsectors containing significant employment opportunities in addition to commerce, a lower value for S was used in calculating trip generation: see Chapter Five and Figure 55.
H: Number of households.
E: Total employment.
* Not capable of meaningful evaluation.
[1] No change overall in Sector 0.

TABLE 51

TRAVEL TO THE CENTRAL TRAFFIC DISTRICT (12 HOURS) 1959, BY MODE: OBSERVED AND COMPUTED VOLUMES FOR TWO GROUPS OF SUBSECTORS

PURPOSE AND MODE	NUMBER OF PERSON TRIPS					
	Group A[1]		*Group B*[2]		*Total*	
	Observed	*Computed*	*Observed*	*Computed*	*Observed*	*Computed*
Work Total	2,716	2,300	3,419	3,365	6,135	5,665
1. Car	1,033	802	1,224	1,239	2,257	2,041
2. Cycle	625	527	1,148	927	1,773	1,454
3. Bus and Train ..	741	739	746	844	1,487	1,583
4. Other Modes ..	317	247	301	383	618	630
Sum of (1 to 4) ..	2,716	2,315	3,419	3,393	6,135	5,708
Shopping Total	1,078	1,129	1,380	1,431	2,458	2,560
1. Car	179	323	375	371	554	694
2. Cycle	59	74	113	117	172	191
3. Bus and Train ..	571	623	663	712	1,234	1,335
4. Other Modes ..	269	198	229	289	498	487
Sum of (1 to 4) ..	1,078	1,218	1,380	1,489	2,458	2,707
Business Total	1,373	1,461	1,742	1,618	3,115	3,079
1. Car	644	705	814	818	1,458	1,523
2. Cycle	59	136	203	194	262	330
3. Bus and Train ..	303	271	380	376	654	647
4. Other Modes ..	367	339	345	297	712	636
Sum of (1 to 4) ..	1,373	1,451	1,742	1,685	3,086	3,136
Work and Shopping and Business Total ..	5,167	4,890	6,541	6,414	11,708	11,304
1. Car	1,856	1,830	2,413	2,428	4,269	4,258
2. Cycle	743	737	1,464	1,238	2,207	1,975
3. Bus and Train ..	1,615	1,633	1,789	1,932	3,375	3,565
4. Other Modes ..	953	784	875	969	1,828	1,753
Sum of (1 to 4) ..	5,167	4,984	6,541	6,567	11,679	11,551

[1] Group A: Subsectors 14, 15, 16, 25, 26, 37, 38.
[2] Group B: Subsectors 13, 23, 24, 36, 45, 46, 85, 93.

TABLE 52

SUBSECTOR GROWTH FACTORS OF INTERNAL TRAVEL[1] 1959-1980: AS USED FOR FRATAR DISTRIBUTION

SUBSECTOR	*Trade Vehicles*	*Car Drivers*	*Cyclists*[2]	*Bus and Train Passengers*	*Other*[3]	*Total People*
11	1.172	1.217	1.115	1.206	1.130	1.169
12	0.715	1.802	1.025	1.346	1.971	1.517
13	2.914	2.288	1.660	3.968	3.684	2.341
14	2.094	2.752	3.498	10.137	3.150	3.178
15	6.437	3.995	4.301	2.174	3.118	3.644
16	3.850	5.381	7.477	4.588	3.764	5.431
21	1.105	1.101	1.669	1.035	1.410	1.257
22	0.951	0.912	1.337	1.759	1.000	1.054
23	1.081	0.790	0.974	3.555	0.819	0.934
24	1.110	1.054	0.966	0.768	0.807	0.951
25	5.785	3.942	3.709	3.029	2.706	3.526
26	1.931	3.182	1.861	1.311	1.333	2.045
31	2.969	1.002	1.266	0.598	1.910	1.116
32	0.746	1.142	1.005	0.791	0.743	0.961
33	0.870	0.815	1.068	0.683	1.098	0.905
34	2.250	0.900	1.270	0.750	1.398	1.029
35	0.766	1.066	0.848	1.459	0.834	0.961
36	1.257	1.212	1.517	1.341	2.780	1.458
37	3.090	4.782	3.582	5.216	3.913	4.291
38	5.704	4.394	2.580	7.120	8.546	4.099
41	1.064	2.474	1.063	2.726	1.131	1.548
42	1.455	0.848	0.740	1.074	0.774	0.827
43	1.767	1.750	1.427	2.619	1.053	1.523
44	0.961	1.273	1.034	1.576	1.284	1.244
45	1.275	1.360	1.183	([4])	1.174	1.265
46	1.579	1.795	1.892	7.620	1.960	2.057
51	1.198	1.353	0.835	0.601	1.529	1.109
52	1.427	0.925	0.712	1.169	0.562	0.791
53	0.637	1.521	0.922	0.766	1.091	1.158
54	1.481	1.908	0.969	4.712	1.075	1.430
55	5.347	4.150	3.083	3.483	2.490	3.437
56	3.261	3.307	2.795	2.411	2.705	2.967
57	1.452	2.957	4.081	1.438	2.800	2.838
58	1.633	1.907	2.417	1.477	0.933	1.626
59	3.213	2.856	4.628	3.940	2.297	3.156
61	1.606	1.857	1.439	0.714	2.936	1.675
62	1.134	1.620	0.688	0.399	0.917	0.973
63	1.933	1.810	1.142	2.000	1.947	1.601
64	1.110	2.937	2.203	1.578	1.478	2.172
65	3.571	4.343	15.135	11.013	2.254	4.896
66	3.338	3.867	9.854	1.108	2.432	3.109
71	1.484	1.751	1.758	0.401	3.385	1.694
72	0.743	0.914	1.940	5.216	0.943	1.226
73	4.229	3.396	2.503	2.640	2.518	2.903
81	1.844	1.418	1.432	1.109	1.673	1.430
82	2.298	1.386	1.379	0.778	1.153	1.262
83	2.106	0.926	0.672	1.532	0.834	0.839
84	0.830	1.502	0.895	2.578	2.094	1.387
85	2.615	2.113	2.105	5.588	2.693	2.391
86	1.000	1.200	1.096	1.150	1.299	1.184
87	2.816	1.657	2.578	2.703	1.448	1.861
91	1.238	1.442	1.112	1.463	0.710	1.164
92	1.305	0.439	1.284	0.551	0.651	0.776
93	4.414	2.711	4.256	6.493	2.511	3.132
01	1.316	1.460	1.194	1.403	1.484	1.385
02	2.626	1.190	1.289	0.513	1.180	1.063
03	1.914	1.319	2.133	1.531	1.160	1.544
04	1.517	1.433	1.290	1.383	1.405	1.369
05	0.907	1.093	1.195	1.134	0.808	1.075
ALL INTERNAL TRAVEL	1.647	1.716	1.491	1.499	1.594	1.598

[1] Excludes external travel impinging on the Internal Area, school trips, and motor vehicle ownership increase 1959 to 1980.
[2] Motor, power, and pedal cyclists.
[3] Passengers in cars, trade vehicles and taxis, plus pedestrians.
[4] In 1959 there were no Bus and Train Passengers in subsector 45 and no growth factor is therefore obtainable. The 1980 estimate is added to subsector 44.

TABLE 53

TRIPS BY CARS, TRADE VEHICLES, TOTAL PEOPLE, AND TOTAL VEHICLES, 1959 AND 1980: BY SUBSECTORS AND LOCALITIES

A. *Passenger Cars and Taxis, 1959:* Intersubsector Trips for a 12 hour weekday (6.30 a.m.-6.30 p.m.) *without* adjustment for 10 percent Transverse Screen Line deficiency.

DESTINATION — Internal Subsectors (columns); ORIGIN — Internal Subsectors (rows)

	01	02	03	04	05	11	12	13	14	15	16	21	22	23	24	25	26	31	32	33	34	35	36	37	38	41	42	43	44	45	46	51	52	53	54	55	56	57	58	59	61	62	63	64	65	66	71	72	73	81	82	83	84	85	86	87	91	92	93	Sub-Total
01																																																												
02	1185																																																											1185
03	1239	61																																																										1300
04	3008	113	291																																																									3412
05	496	67	107	90																																																								760
11	974	1	73	114	26																																																							1188
12	867	55		222	8	127																																																						1279
13	1149	123		187	6	453	54																																																					1967
14	2769	101		342	12	351	401	1070																																																				5046
15	1040	101		406	11	664		693	1721																																																			4636
16	2463	292	245	380	182	1189	397	679	2091	1460																																																		9328
21	1167	35	5	176	62	10				108	-																																																	1563
22	1032	63	73	49	34	105		83			85	36																																																1560
23	1010	13		19	13	100	61	344	107	34	172	27	48																																															1948
24	983	16	57	85	1	54	41	67	134	80	270	59	73	42																																														1962
25	2702	14	305	644		235	188	789	746	203		255	122	295	444																																													6942
26	1275		54	404	53	84		195			628			193	73	483																																												3442
31	890	53		231	3	40	45	107				33	73	2	2	271	-																																											1750
32	821	31	30	284	11	59		6	131		117	55		88		147	12	31																																										1823
33	966	78	58	100	32	101	22	37	87	188		58	67	42	15	329	312	49	23																																									2569
34	690	64		220	19	4	43		79	112		4	36	20				20	221	97																																								1629
35	887		36	160	76	63		3	89			22	35	52	125	157	118		4	215	58																																							2100
36	1057			144	19	39		73		252	107	209		26	58	267	381		9	78	121	97																																						2937
37	1700	250		20	27	155			28	293			425	64	133	1154	458	12	89	210		736	-																																					5754
38	2152	135		363	13	250	582		252		622	15		85	228	267		400	17		15	439	237	1680																																				7752
41	724		169	125	10	88		120											12	48			11		-																																			1307
42	865	72	83	68	5	114							2			220	66		9	4	32	2	39	49		204																																		1894
43	1173	34	126	645		34								32			148	54			6	24	36	157			26																																	2495
44	838		5	106	56	59	6	61		94		58					60		16	133	10	2	83				28	-																																1615
45	904	69	47	45			69			78		39			3	127		64	18	3	8	20	105	73	483	67	34		177																															2493
46	1608	32	36	64	51	29	6			144		10		78		458		22	38	69	70	78	29	383	361	15	88	110	82	47																														3908
51	904	53	207	192	22								84		11	77							123	161			49		70	23	122																													2098
52	700			69		60	22	62			74					122		13	1	19	47	58	56	68		48	44	74		27	43	37																												1644
53	777	5	86	408		5					22	5			32		14					4				6	4	16	3	23	103	61	88																											1662
54	1000	6	7	33							372								6	4		59	52					52			134	97	45	217																										2084
55	824		113	63	113		323	179	115				39			716				4				278						13	67		9	122	-																									2978
56	1501			853	212	48						104		41			298				107						77	112	6		327	316	107	321		326																								4256
57	509			15	39	40								27		29							68	201			97	56	4	36	117			85	102	886	528																							2839
58	944	28	32	160		36	51					21							3	16	44				117		24	44	91	50	6		21	124	152	534	533	651																						3682
59	1087	79	95	208	8	143			142			108		31	76			41						165					67	74	237					123	165	1541	638																					5001
61	770	5	316	46	13	5	6				204	43	89		4	376				23					217		73	71		23	71	13	33	29	8	64	480	88		-																				3070
62	657		44	214		28			84				40	38						30		40			102	92			41		3	30		231		17	96			119	46																			1952
63	942		162	234		41					125								6			26		265		88		173	39	32		29	35		46	183		48	58		201	86																		2819
64	1158	132	101	236				136				46			51	287							8	179							58		35	11	68	515		96	187	246		98	168																	3816
65	1094	100	83	267		123			183		1118							52											6		242		235		217			107			135		146	212																4320
66	498			364	116						19	123	89					51						199																	239			288	1052															3038
71	860	39	127	801	11	108		51	49						55		157	57							77	81	52	94	92		9	86	54		10					153	68	28	108	165		-														3392
72	1139		4	462					3				28		14	65		2	31	23	32					80								2				3			8	86	2	91	82		174													2331
73	1516	126	65	44	87		142	185	177	200		96	134			182	274	50	105			86	66			286		213	128	70	15			142	17	199			14	152	201	16	203	494	151	412	249	214												6711
81	772	48	26	227	4	134		3	194	151	117	19	95	31	29	106	75	23	74	105	40	59	19	468	413	266	79	46	6	96	113		30	35		115	352	53	6		130	177	63	53	205	77	142	215	248											5739
82	693	5	24	107	50	114		85	74	178	120	47					127			69	41				163		3						19			14		114								121	165		28	101										2462
83	663	3	21	243	6	42		55	51	92					14					26				144										40		85					37							15		165	151									1853
84	690	45	54	320		94		9	9		208			16	48	114						25		114		28	22		30		66	77		6			158					7		125		175	143	37		116	62	24								2822
85	1455	41		172	73	113	42	84	115		555			25					67				77				46				196			10					106	157	81						76	183		36		70	-							3780
86	1039	4	48	281	7	30									6					3				134										33			194		28		5		51					40	224	194	5	64	132	314						2836
87	1937	121		222	57	137		62	44	209	114					121			6	4	33		45		9	90					7					100						3					229	17	607	515	82	30	69	21	396					5237
91	831		105	312	21	75	63		77	93	190		17	25		104	5				84	2	41	110		204	4			29		6	32		227			21	6			60	99		91		48	47	142	74	213	59	36	107	101	-				3761
92	747		8	94	4	36	14	29	28			7			1	53	30					1		22		64			1		9							23										9	21	37	13	1		21	11		47			1331
93	1957	41	111	410	132	292	219	89	405		465					853						8		169	38		7		5		166											219								320	12		51	636	42	83	213	232		7175
Sub-Total	66293	2704	3639	12250	1705	6111	2797	5356	7218	3969	5704	1499	1496	1253	1422	7085	2535	941	755	1183	748	1766	1095	5019	1980	1619	757	1061	848	543	2111	752	743	1408	847	3461	2506	2718	1043	827	1151	780	840	1428	1581	785	1226	777	1270	1558	538	248	288	1099	500	83	260	232		182108

B. *Passenger Cars and Taxis, 1980:* Intersubsector Trips for a 12 hour weekday (6.30 a.m.-6.30 p.m.) *without* adjustment for 10 percent Transverse Screen Line deficiency or vehicle ownership increase.

TABLE 53—*continued*

DESTINATION —— External Localities

ORIGIN — Internal Subsectors	001	002	003	004	005	006	007	008	009	101	102	103	104	105	106	107	108	109	301	302	303	304	305	306	307	308	309	401	402	403	404	405	406	407	408	409	501	601	602	801	802	901	902	903	904	905	Sub-Total	Grand Total
01	169	174	84	184	9	78	10	28	13	107	196	227	107	76	79	72	47	5	72	452	83	266	74	98	50	24	34	142	101	21	6	232	100	53	18	165	34	224	27	124		458	183	41	16	53		4816
02		9								2	4	4	4		2				6	8		4				3		2	2			2				6		3		4		16	2					83
03	4						2	2		1	2	2	4						2	7	4							6								7	2	5				2	4			2		58
04	6	2		2	1			2		13	7	2	9	3	2	2	5		8	16	6	12	2	2	2	2		8	2			12						7		6		24	6					171
05	2	15	2	5		5				9	10	8	6		3		2		3	14	2	10	4	4		2		2		2		4	2			11	2	5		2		11	12		3	2		164
11	24	25	24	48		13	5	3	2	69	58	58	39	10	16	2	6		24	60	9	35	10	18	2	4	4	13	30	6		36	10	2	2	11	12	26		10		92	38	2	14	7		879
12	3	7				2					6		4								2	9										2										19						54
13	50	11	2	7				2		10	14	6	81	2					48	31	7	10	4				2	20	6			9		2		12		18		2		24	3	2				385
14	46	9		4	2					42	17		7		2				6	6	3	2	5				2	19	2						2	4				2		27	6			3		218
15	26	20	10	2						2	2		65	18	10	6	3					2						16				3				4						8	2					199
16	173	89	15	7		4				61	33	12	57	22	10	6			16	24	2	13	10	8				16				16				13		5		16		94	3					726
21	2	2						2			7			2					4	21			5					2						4		2	2	7				18	2			2		84
22		TRANSFERRED				TO	21																																									
23	11	6		7	2	7				4	9	2	9	4	4		2		39	52	6	11	4	2			6	6				23	2	2		10		11		2		12	11			2		268
24	8			2	2	7					6	2	6	2					32	52		5	4	4				35								12		4		6		26	2					217
25	8	5					2	4			7	7	11	4		2			99	49	2	20	2				2	33	2			5	3			8						17	3					295
26						TO	24																																									
31						TO	33																																									
32	10	2		2							7		2	2	3					31	11	17	4	9			2	21	2			8		4		17	4	11	1	6		26		2				204
33	2	6	2	13		6			2	6	12		4	2	5				3	95	5	22	10	8				26	4	2		12		8		25		16	1	6		6	2			2		313
34						TO	32																																									
35	9	5	2	6	3	5		1	1	6	3	3	4	2	3	5	2	1	117	350	41	49	21	4	2			45			2	10	10			41	4	17	9			13	7			3		806
36						TO	35																																									
37						5					1					1			20	12		6						16								4		3					1		2			71
38		1		3												2			6	84		11						22				4				6		5										144
41		2								2					2		2			14	4	13		2		2		17				4		3		14		2				2				2		87
42						TO	41																																									
43			2																	18	9	2	2				2	2				2		2		23		5										69
44	2	2	2		2					7	8	2				4				93	26	36	6			4	5	80	14			16	6	4		57	10	4				4				2		396
45	2		1			2							4				1			11	3	2						15								15						2						58
46			2				2				2								6	39	13	13				3		46	6			2		5		57		2				4				22		224
51						TO	53																																									
52				2		2									3					10	6	4						11				4		2		10		3				2	2					61
53	4	2	2	4		2				2	8			2		2				49	11	8	4	4				17	2			4		2		26		20	4			2	6					187
54						TO	53																																									
55											4								1	10	1	4						2				7				16		.	4	2	1	6	2					60
56												2								15	8	4						5	2			9	2	3		14		6		2		3						75
57	3			7	1	4							2	2	5	1			2	33	14	9	3		1			10				2	3	4		57	1	5		2		11		2				184
58		2				2					6									18	10	9				1		13				3				21	1	9				7						102
59	4	6											6							43	1	16		1	1		1	3		2			1	1		58		1										145
61																					2														1													3
62	2	11								4										4	2	2						2								9		7				2	2					47
63						TO	62																																									
64										21	4	10	6			2	2			20		8		2				6	5			8		2		20		27		5		11	7					166
65											4						2		6	2		2						2	4							8		28										58
66		2																		11		4	2									4				3		132	22									180
71																	4				2		2					9	2									2				2						23
72				9		2		2			4	2	2		4				8	16		11		2				2				7	2		2	27		26		6		16	3			2		155
73																3				2			3					4				3				2						2						19
81	4	5		5						8	3	2			2	4			3	21	4	9	8					2				4				8		1		6		41	6			5		151
82	4			6		2				6	13			3			2		9			3		4								2				2		3	4	4		24	4					95
83								2																				2				2				3				2		14						25
84						TO	81																																									
85						TO	87																																									
86	2										3								11	2		2						2	2				2			12		2				12	3					55
87	4		2	4						1	18	1	11		2				6	16	6	9	2	2		4	2	4	2			2	4	2		11	4			10		53	2					184
91	12	19		7		3				14	23	14	4							16	2	12	2					11				8	2	3		8				16		85	19	2	9	2		293
92	6	3		12		2			2	2	2	3								17	6	10	6	2		3		1	2			4			2	17		5		16		81	10	2				216
93	9	2				2				8	2		11				2			22	2											2				2	3			20		95	6					188
Sub-Total	611	444	152	348	22	155	21	48	20	407	505	369	465	156	157	114	82	6	557	1866	315	696	199	176	58	52	62	718	192	33	8	477	149	108	27	858	79	657	72	277	1	1374	359	53	44	111		13660

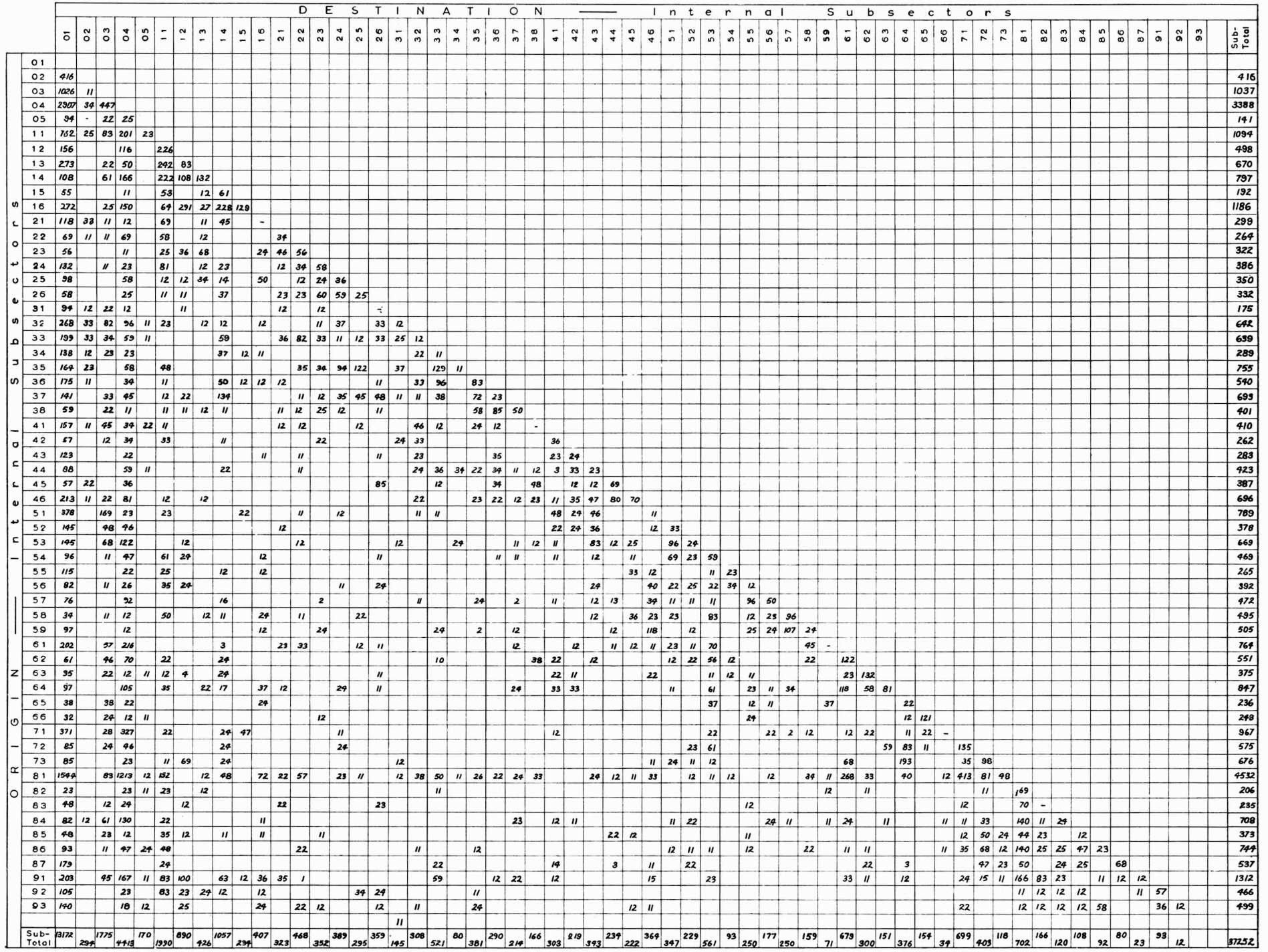
C. *Passenger Cars and Taxis, 1959:* External-Internal Trips for a 12 hour weekday (6.30 a.m.-6.30 p.m.) *without* adjustment for 10 percent Transverse Screen Line deficiency.

Origin — Internal Subsectors	001	002	003	004	005	006	007	008	009	101	102	103	104	105	106	107	108	109	301	302	303	304	305	306	307	308	309	401	402	403	404	405	406	407	408	409	501	601	602	801	802	901	902	903	904	905	Sub-Total	Grand Total
01	172	160	116	248	14	98	28	32	14	174	218	288	160	82	78	76	68	14	116	600	100	630	112	110	64	32	50	230	96	22	14	386	118	90	16	136	48	320	48	152		1088	262	64	26	62		7032
02		5								1	3	3	3		4				8	11		5				4		2	3			2				11		9		4		10	2					90
03	4						3	3		1	2	2	6						3	14	6							10								6	2	21				5	4			2		94
04	5	1		2	1			3		13	6	2	10	2	4	4	6		14	28	8	22	3	2	3	3		12	3			14						27		8		199	5					410
05	1	9	2	5		6				8	7	6	6		5		3		4	19	2	14	6	6		3		3		3		3	2			8	2	16		2		17	9		3	2		182
11	15	14	25	52		16		5	4	62	45	44	38	6	25	4	7		34	87	10	53	14	26	3	5	4	16	32	7		34	13	1	5	8	11	85		7		174	28		14	9		1042
12	2	4				2					4		4									14										2										24						56
13	58	12	2	7				3		16	20	8	140	2					125	82	14	27	11				2	44	11			15		1		17		105		2		70	4					798
14	85	15		4	2					107	37		19		4				25	25	9	9	21				3	67	6						5	8				4		139	13			5		612
15	47	33	10	2						5	4		175	28	16	11	3					8						5[illegible]				8				8						135	4					552
16	464	218	16	7		5				226	105	37	229	50	16	11			96	145	9	81	61	13				82				64				41		68		44		539	9					2636
21	1	1						3			5			1					5	29			7					3						3		14	2	22				32	2			2		132
22																																																
23	9	5		7	2	8				5	9	2	12	3	6		3		74	99	9	22	8	2			7	10				28	2			10		47		2		31	10			2		434
24	5			2	2	8					4	2	6	1					40	67		7	6	6				39						1		7		11		4		46	2					266
25	14	9						6			16	15	29	6		4			395	200	6	84	8				3	112	6			14	4			17						70	6					1024
26																																																
31																																																
32	5	1		2							4		2	1	5					39	10	22	6	13			2	22	1			7		3		11	3	31	1	3		52						246
33	1	3	2	14		7			4	4	7		3	1	8				3	104	5	25	11	12				24	4	1		9		6		14		40	1	3		9	1			2		328
34																																																
35	5	2	2	6	4	6		1	1	4	2	2	3	1	5	9	3		138	417	36	61	26	6	3			46			2	8	13			25	3	45	7			40	4			4		940
36																																																
37						6					3					1			97	59		30						67								10		33					2		2			310
38		2		4												4			31	437		60						96				14				16		58										722
41		1								2					4		3			25	6	24		2		3		26				5		3		13		8				3				2		130
42																																																
43			2																	36	14	5	4				2	4				3		1		24		23				6						124
44	1	1	2		2					6	6	2				6				134	29	53	9			5	6	97	15			15	8	3		43	9	13				11				2		478
45	2		1			2							4							18	3	34						22								13						5						104
46			2																16	107	27	37				4		107	12			3		4		82		13				15				29		458
51																																																
52				2		2									5					12	6	5						11				3		1		5		7				6	1					66
53	3	1	2	4		2				2	6			1		4				74	13	13	7	6				22	3			4		1		20		69	4			11	4					276
54																																																
55											8								4	39	3	16						6				18				33			4	4		37	4					176
56												3								53	22	14						15	5			21	2	3		26		47		3		22						236
57	4			7	1	5							4	2	8	1			6	98	31	28	9		1			25				4	5	3		88	2	33		2		63						430
58		2				2					7									41	17	21				1		25				4				24	1	46				27						218
59	6	9											14							151	2	59		1	1		1	9		6			1	1		105		9										375
61																					1														1													2
62	1	6								4										5	2	28						3								6		21				6	2					84
63																																																
64										34	5	13	10			4	2			52		22		2				13	10			14		2		27		155		6		21	10					402
65											11						2		30	11		11						9	15							22		60				3						174
66		2																		32		13	6									8				4		161	18			2						246
71																	4				3		4					15	3									9				6						44
72				10		2		3			4	2	2		6				14	29		20						3				9	2		5	25		103		5		20	2			2		268
73																5				8			11					12				7										19						62
81	3	4		5						9	3	2			4	6			5	35	5	15	13					5				4				7		4		7		52	5			7		200
82	4			6		2				7	13			2			2		16			5		2								8				1		12	4	3		58	3					148
83								3																				3				2				2				2		26						38
84																																																
85																																																
86	1										3								12	3		3						3	2				2			6		5				18	2					60
87	4		2	4						1	21	1	16		4				13	34	10	21	4	2		4	2	7	4			3	6	1		13	5			10		184	2					378
91	8	12		7		4				13	19	11	4							25	2	19	3					14				9	2	3		6				12		154	15		8	2		352
92	3	1		13		2			3	1	1	2								18	5	11	7	2		4		1	1			3			4	9		11		8		119	5					234
93	17	4				2				21	4		30				2			90	6											5				4	7			37		335	12					576
Sub-Total	950	537	186	420	28	187	31	62	26	726	612	447	929	189	207	150	108	14	1324	3592	431	1651	377	213	75	68	82	1397	232	39	16	760	180	131	36	975	95	1747	87	334	-	3909	434	64	53	134		24245

Column heading: DESTINATION — External Localities

D. *Passenger Cars and Taxis, 1980:* External-Internal Trips for a 12 hour weekday (6.30 a.m.-6.30 p.m.) *without* adjustment for 10 percent Transverse Screen Line deficiency or vehicle ownership increase.

TABLE 53—*continued*



E. *Trade Vehicles, 1959:* Intersubsector Trips for a 12 hour weekday (6.30 a.m.-6.30 p.m.) *without* adjustment for 10 percent Transverse Screen Line deficiency.

DESTINATION — Internal Subsectors

Origin (Internal Subsectors)	01	02	03	04	05	11	12	13	14	15	16	21	22	23	24	25	26
01																	
02	462																
03	1285	51															
04	3456	112	806														
05	147		24	20													
11	856	61	109	188	13												
12	156			50		70											
13	250		82	133		467	74										
14	306		128	248		237	53	400									
15	212			51		177		113	315								
16	483		101	426		131	273	157	738	1282							
21	318	82	15	12		48		22	51		-						
22	132	23	13	57		35		21				21					
23	51			8		14	9	103			39	26	27				
24	100		15	23		58		24	26			9	22	33			
25	486			326		49	23	338	91		616		44	78	154		
26	385			41		13	6		69			28	24	56	73	176	
31	131	82	84	33			10					25		19			-
32	131	52	70	59	4	10		15	8		16			4	17		25
33	172	70	40	49	6				57			22	44	16	7	44	35
34	58	60	63	45					83	93	47						
35	153	27		26		15							10	8	32	237	
36	155	24		29		7			48	35	22	8					12
37	218		104	101		20	16		342				16	16	60	439	135
38	240		201	72		52	25	161	83			54	51	95	60		90
41	177	30	67	36	14	9						10	8			55	
42	159		27	54		38			20					20			
43	73			43							48		14				27
44	49			55	6				24				7				
45	63	45		28													84
46	107	31	33	87		9		26									
51	344		236	23		17				79			7		9		
52	65		82	56								11					
53	190		53	67			2						4				
54	48		20	61		58	10				34						18
55	138			109		91			68		130						
56	435		49	82		81	26								27		96
57	131			81					16					1			
58	74		22	17		51		34	18		74		10			134	
59	89			32							70			37			
61	342		110	295					5			24	29			71	19
62	207		56	60		14			24								
63	102		74	29	16	21	3		67								33
64	110			68		17		29	13		53	6			12		9
65	58		116	55							130						
66	18		70	25	14									14			
71	546		46	378		18			32	193					10		
72	35		18	25					15						10		
73	547			125		44	131		153								
81	1925		198	2068	12	189		42	95		271	28	63		30	81	
82	174			48	14	35		52									
83	4		29	41			7					28					49
84	152	20	56	84		10					16						
85	74		55	20		43	7		21		40			11			
86	104		14	42	13	31							13				
87	118					38											
91	396		68	179	7	65	36		77	46	85	28	1				
92	34			21		56	7	45	13		24					136	28
93	299			82	33		39				243		65	32			69
Sub-Total	17725	770	3354	6473	152	2338	757	1632	2572	1728	1958	328	459	440	501	1373	729

Origin (Internal Subsectors)	31	32	33	34	35	36	37	38	41	42	43	44	45	46	51	52	53	54	55	56	57	58	59
01																							
02																							
03																							
04																							
05																							
11																							
12																							
13																							
14																							
15																							
16																							
21																							
22																							
23																							
24																							
25																							
26																							
31																							
32	15																						
33	44	5																					
34		21	14																				
35	35		38	7																			
36		13	53		24																		
37	52	12	56		56	33																	
38					133	366	572																
41		23	8		9	8		-															
42	79	25							46														
43		22				45			37	57													
44		11	22	48	7	21	18	57	2	38	33												
45			6			18		195		12	15	39											
46		11			8	15	22	127	10	46	78	63	46										
51		5	7						39	29	69			9									
52									22	36	67			12	31								
53	14			20			11	34	5		70	5	9		40	13							
54						9	25		12		23		9		68	28	32						
55													100	50			23	113					
56											116			107	54	75	30	108	147				
57		5			7		3		8		17	8		25	8	9	4		325	110			
58											26		31	27	25		50		65	79	92		
59			42		2		56					24		262		30			257	159	196	70	
61							29			20		11	10	13	24	14	41					67	-
62			6					165	15		16				8	18	20	10				20	
63									43	32				44			11	29	101				
64							27		18	27					6		17		57	18	15		
65																	39		114	67			189
66																			186				
71									12								11			63	2	15	
72																12	14						
73	135													51	101	56	28						
81	43	31	55	28	15	25	72	283			62	15	12	47		19	8	20		50		62	39
82			15																				53
83																			78				
84							26		6	9					6	14				39	5		15
85												27	12						71				
86		5			4										8	9	4		42			21	
87			31						25			5		20		45							
91			41			8	41		11					13			10						
92					4																		
93		24			38								34	42									
Sub-Total	417	213	394	103	307	548	902	861	311	306	592	197	263	722	379	342	342	280	1443	585	310	255	296

Origin (Internal Subsectors)	61	62	63	64	65	66	71	72	73	81	82	83	84	85	86	87	91	92	93		Sub-Total
01																					
02																					462
03																					1336
04																					4374
05																					191
11																					1227
12																					276
13																					1006
14																					1372
15																					868
16																					3591
21																					548
22																					302
23																					277
24																					310
25																					2255
26																					871
31																					384
32																					426
33																					611
34																					484
35																					588
36																					430
37																					1676
38																					2255
41																					454
42																					468
43																					366
44																					398
45																					505
46																					719
51																					873
52																					382
53																					537
54																					455
55																					822
56																					1433
57																					758
58																					829
59																					1326
61																					1124
62	112																				751
63	58	210																			873
64	82	25	99																		708
65				27																	795
66				12	451																790
71	15	17		6	49	-															1413
72			59	22	11		65														286
73	393			540			172	224													2700
81	483	37		35		32	630	58	341												7504
82		15						10		192											608
83							18			157	-										411
84	17		13			11	7	9		121	12	21									669
85							18	35	174	98	63		10								779
86	10	7				16	28	25	45	165	37	30	21	27							721
87		32		3				43	210	142		69	28		103						912
91	37	8		7			23	7	50	233	145	32		15	9	22					1700
92										13	18	15	6			17	44				481
93							91			72	89	72	28	343			136	39			1865
Sub-Total	1207	351	171	652	511	59	1052	411	820	1193	364	239	93	385	112	39	180	39			61535

F. *Trade Vehicles, 1980:* Intersubsector Trips for a 12 hour weekday (6.30 a.m.-6.30 p.m.) *without* adjustment for 10 percent Transverse Screen Line deficiency or vehicle ownership increase.

DESTINATION — External Localities

Origin (Internal Subsectors)	001	002	003	004	005	006	007	008	009	101	102	103	104	105	106	107	108	109	301	302	303	304	305	306	307	308	309	401	402	403	404	405	406	407	408	409	501	601	602	801	802	901	902	903	904	905	Sub-Total	Grand Total
01	33	67	14	34	3	12		4	2	59	43	51	22	17	16	28	17		38	226	38	74	14	28	2		2	77	16		2	64	31	18	2	35	16	79	9	23		123	47	18	15	10		1429
02		2										3						2	3	4	2			3					6				2	2				2					31
03										16	1	2		2					9		10					3	3								2		11		2		5	3					69
04		6								22	6	10		3	11			9	18		8						4			9		2			3	17		6		21	3	1				159
05											3	3		2						5		4									2		2		7						4					32
11	10	25	34	47		2				20	23	53	14	13	12	8	2		10	56	12	20	8	8	6		2	9	23		4	31	2	6		3	6	2		12		40	12	2	2	19		558
12	2	11	7	2								3	8		2	1		2		6	2	4		5			2	8				3	3		3			2				6	2						84
13	6	3							9			4	4					10	9	8	4					9				2	5			2		8		2		21	2						108
14	17	4		3				3	2	9	39		4	3						12	4		4	6			8				2		3	2	2	2						5	7			3		144
15	14	14	8									26	15	8	1			2	8		4						10															4					114
16	61	49	14	5	6	2				9	6	2	43	11	6	5				35	13	17		2				12				15				5	3	5		14		87	3	2		2		434
21														1			2																										8					11
22																																															-
23	4											2						10	9	2	6										3				6						15					57
24																			14	28				2				21								4	2			2		16					89
25	1	16		3						2		2	5		2				31	9	2	6	2					9								2		2				11	5				110
26																																															-
31																																															-
32	4									2			17			3				2		4						2				2				8		5		2		5					56
33		5										10			3			4	6	2							1				2				9		9				4					55
34																																															-
35	4	3							1			1	5	1		1			19	64	26	13			2	5		35	2			6	3	2		21	7	1		4		13				3		242
36																																															-
37																			11	8									15								2		2							1			39
38													1						2	28	4	2	2					12				2				6		3											62
41																				2		2	3					6								4												17
42																																															-
43													2							5	2							3																						12
44		6								1	4		32						4	40	16	8		3				19				4				15						9					161
45																				2								3				3				3												11
46												3							19	24	3						2	3			5				16											75
51																																															-
52	2																		4																		3											9
53		5		2						2	3					4				2	2	2	3									1				9				10		50					95
54																																															-
55			2									3						90	8	3	7											3	2		3	11		6				3				141
56																				13	7	4						3								6			19	2		8		2				64
57		4									3	9						12	6	2						4								2		2		10		54					108
58																			4	11	7						5				3	2			9				2		7					50
59																				12	2	1						1				1	4		9											30
61		3																		2	11																									16
62	4	7	3	6						2								2																			3		2		6		3				38
63																																															-
64		4								3	6							10	8	3		2										2			2		5				11					56
65											5																	5	1									2	3		2		3					21
66		2																				2																	15	10			5					34
71																				10								3								3							1	2				19
72															2				10	5	2											3	3	3		7		4		7					46
73																					3																										3
81		10			1														19		3					4	2			3					6				20					68
82																				7																						6	2				15
83																																									6					6
84																																															-
85																																															-
86																				2		3																2				8					15
87											2							24	4							6														24					60
91	6	27	6	4	2		2			2	9	16		8	2	5	2			7	4						2	2			4					2	2		4		27	12	2				159
92	2		3															7	2			2				5				2	2				1		4		30	2		2			64
93	7																			4	3																	2		2		30	5						53
Sub-Total	177	273	91	106	12	16	2	7	5	153	149	155	210	80	61	59	23	2	289	752	212	239	35	58	10	8	9	301	54	-	6	174	54	42	10	200	56	197	44	109	-	702	110	30	20	37		5329

G. *Trade Vehicles, 1959:* External-Internal Trips for a 12 hour weekday (6.30 a.m.-6.30 p.m.) *without* adjustment for 10 percent Transverse Screen Line deficiency.

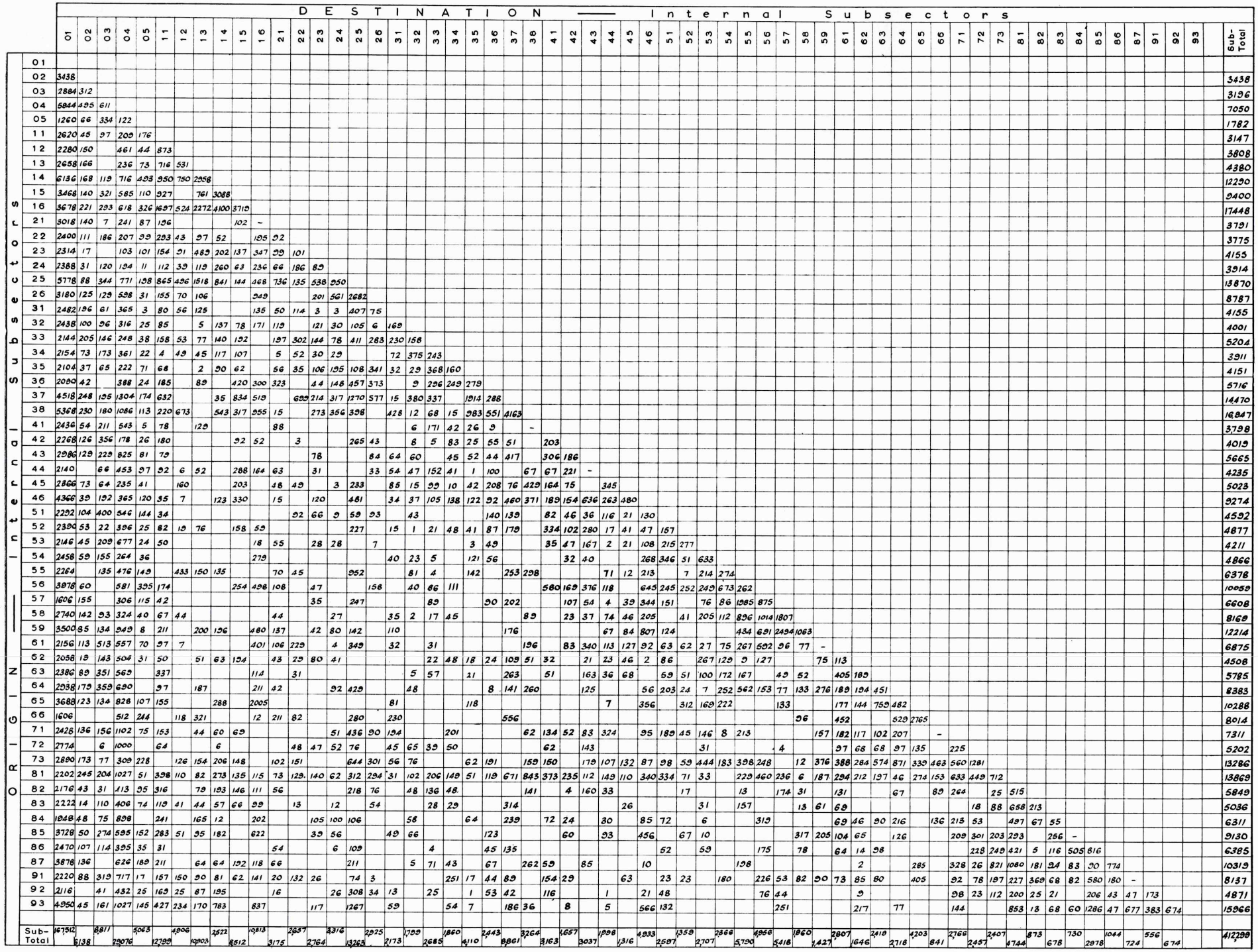
ORIGIN — Internal Subsectors	001	002	003	004	005	006	007	008	009	101	102	103	104	105	106	107	108	109	301	302	303	304	305	306	307	308	309	401	402	403	404	405	406	407	408	409	501	601	602	801	802	901	902	903	904	905	Sub-Total	Grand Total
01	42	86	10	54	8	20		6		110	62	42	46	16	4	32	18		100	460	50	96	12	36	4			114	12			112	54	24	6	38	14	230	14	56		250	42	20	22	10		2332
02		2										4						3	4	7	4			4					10				3	2					4					47
03										24	1	4		2						10		16					4	5								2		17		2		9	3				99
04		4								30	5	15		2	13				10	17		12								6			12		3			2	206		4		33	3	2			379
05												2	3		3						4		5											2		3			6						5					31
11	6	15	41	57		2				23	17	65	13	7	16	11	3		10	45	11	23	11	10	8		3	11	30		12	34	2	7		3	4	45		7		53	9	2	2	23		641
12	1	4	8	2						20	3	5		3	1		3		3	1	3		6			3	6				2	4		4			3				5	1				71
13	8	3								20			8	4					19	14	14	10						22				5	6			3		27		3		56	3				225
14	21	5		4				4	3	19	52		7	4						17	6		10	7				18				4		4	3	3	2	25				11	9			4		242
15	46	40	10										123	38	11	1			10	32		23						60											25				26						445
16	118	83	17	6	7	2				30	13	7	119	16	8	7				82	35	59		2				43				48				12	6	70		24		335	7	2		2		1160
21															1			3																														11						15
22																																															
23	2													2						9	6	2	6										3				5						18						53
24																			12	21				2					23								3	2			1		19						83
25	3	43		4						10		11	22		3				134	33	8	32	13					50								8		3				67	18				462
26																																															
31																																															
32	2									2			10			4				1		3						2				1				4		8		1		4						42
33		2											7			4			3	4	1							1				2				6		8				4						42
34																																															
35	2	1							1			1	3	1		1			12	32	18	10			3	7		27	1			5	4	2		12	3	8		1		11				4		170
36																																															
37																			24	15								43								4		3								1			90
38													4						9	110	17	12	13						71				10				24		4											274
41																				1		2	4					8								3													18
42																																															
43														3							6	3							4																					16
44		3								1	2		23						3	25	11	7		4				18				4				10							9						120
45																					1								4				4				3													12
46												4								16	24	4						3	4			6				15													76
51																																															
52	1																				3																				4												8
53		2		2						2	2				5				1	1	1	2											1				5				3			40						67
54																																															
55			2											9						273	21	9	27													4	2		8	25	23	7					8						418
56																					30	19	14						11								15			23	3		31		2				148
57		3											4	11						12	7	3						6								2		3		7		91						149
58																				5	13	9						8				5	2			11				2		14						69
59																					23	4	3						3				1	5		17													56
61		3																			3	18																		26											50
62	3	5	4	7								2								1																			5		1			9		3				40
63																																															-
64		2										2	7								8	7	4		2										2			2		8					15						59
65												11																		19	4									5	5		4			12						60
66		3																					6																			20	12				18						59
71																						10								4								3		26					2	2						47
72																3							5	3	2														4	4	2		7		1			5						36
73																								9																				45											54
81		8			2																21		5						7	3			5						200					36						287
82																						13																									18	3						34
83																																											12						12
84																																															
85																																															
86																					1		3																		3					9						16
87											2								41	6								13															57						119
91	4	17	7	5	2		3			3	7	22		5	3	7	3			6	4							3	3			5						2	7		3		39	10	2			172
92	1		3																		6	2			2				6				2	2						2		3		38	2		2			71
93	15																				11	9																			3		4		131	13					186
Sub-Total	275	334	102	141	19	24	3	10	4	274	180	188	419	97	64	73	27	3	675	1149	291	417	67	71	15	11	10	610	66		12	282	81	54	17	232	67	1069	56	130		1507	133	33	27	43		9362

H. *Trade Vehicles, 1980:* External-Internal Trips for a 12 hour weekday (6.30 a.m.-6.30 p.m.) *without* adjustment for 10 percent Transverse Screen Line deficiency or vehicle ownership increase.

DESTINATION —— Internal Subsectors (columns); ORIGIN —— Internal Subsectors (rows)

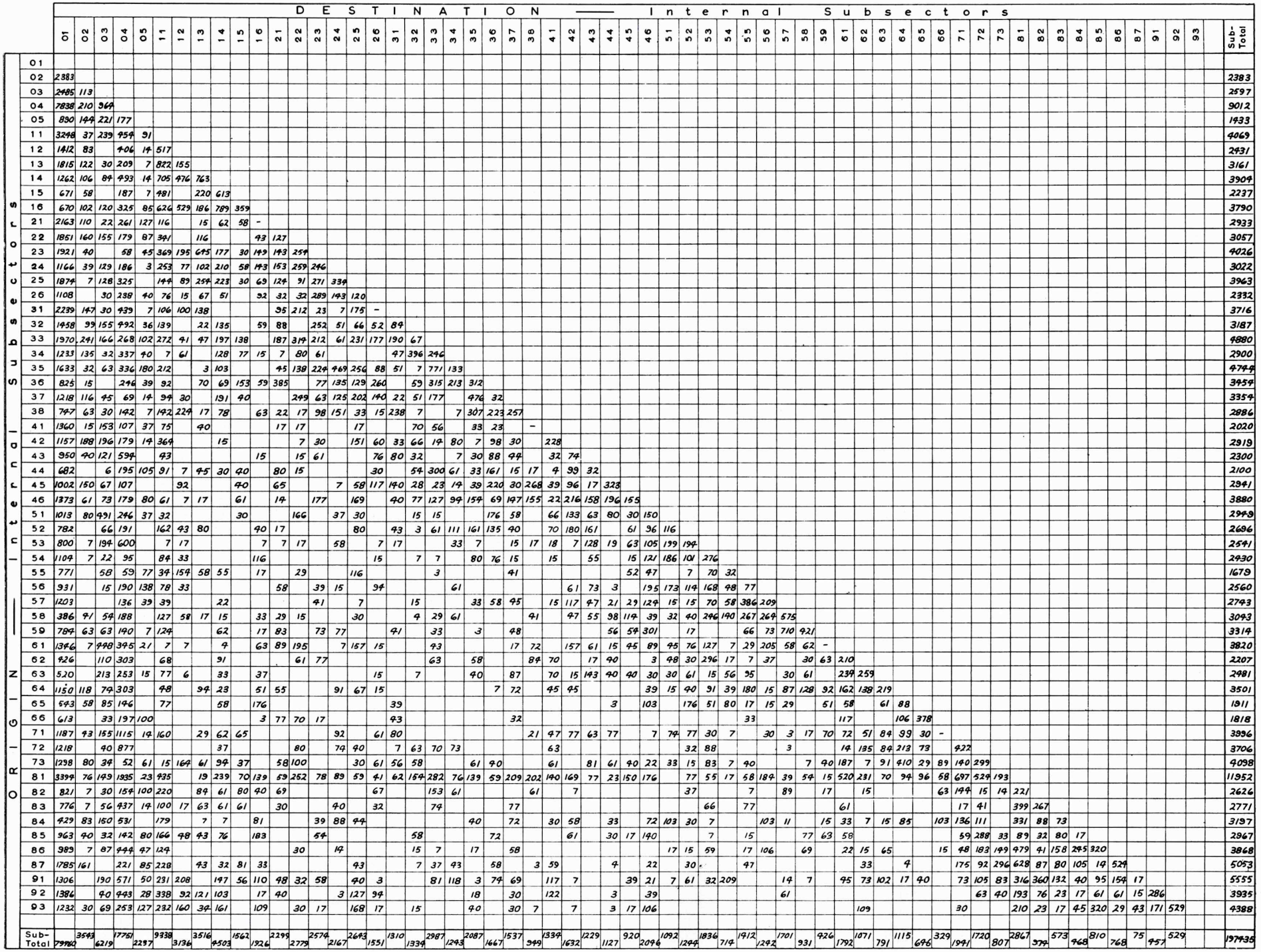
Origin	01	02	03	04	05	11	12	13	14	15	16	21	22	23	24	25	26	31	32	33	34	35	36	37	38	41	42	43	44	45	46	51	52	53	54	55	56	57	58	59	61	62	63	64	65	66	71	72	73	81	82	83	84	85	86	87	91	92	93	Sub-Total
01																																																												
02	4132																																																											4132
03	2791	566																																																										3357
04	5649	592	591																																																									6832
05	1405	100	334	138																																																								1977
11	3161	66	86	220	272																																																							3805
12	2250	166		427	46	1500																																																						4389
13	2041	131		462	62	636	882																																																					4214
14	1666	93	176	290	323	574	464	2879																																																				6465
15	1579	71	102	313	58	500		208	1020																																																			3851
16	1090	74	62	249	124	601	140	439	646	988																																																		4413
21	3969	144		220	221	221	46		44	42	-																																																	4407
22	2711	296	160	163	146	517	286	160	29		91	463																																																5022
23	2869	29		175	285	265	127	568	150	88	169	680	603																																															6008
24	2062	57	223	314	23	215	51	166	190	42	104	84	576	464																																														4571
25	2564	174	88	238	95	375	169	408	320	22	48	252	131	1259	609																																													6752
26	1762	101	66	385	29	132	44	44			185		268	374	826	1100																																												5316
31	4211	564	56	438	46	119	62	100			23	401	292	134	126	216	62																																											6850
32	2758	500	137	363	29	129		4	86	42	62	133		228	58	48		241																																										4818
33	3419	278	132	273	58	237	60	81	84	100		311	1070	268	393	393	257	496	368																																									8268
34	2250	193	130	331	29		44	29	56	44			58	44	44			101	673	625																																								4651
35	3915	73	70	481	160	140		2	75	44		85	165	255	667	64	371	126	58	1053	388																																							7642
36	1709	210	42	308	56	196	21	138	44	155	73	268	42	269	516	142	268			619	425	1500																																						7001
37	1646	84	42	367	56	226				102	42		226	86	452	130	316	42	135	509		1251	254																																					5966
38	1275	161	46	393	46	92	212		92	46	92			243	182	48		168		74		629	1896	759																																				6404
41	2176	174	110	350		66		58				58							84	190	29	29			-																																			3324
42	2247	287	907	282	44	334				58	22		21			142	44				124	58	56	22		907																																		5055
43	1784	117	317	588	90	75								88			44	58	58	44	29	66	29	90		209	455																																	4136
44	2247	44	252	372	118	110		33		117	44	58	44	44			22	62	141	226	73	2	78		44	44	1194	44																																5413
45	2003	182	49	340	56		151			88		42	119			84	84	102		203	42	70	308	22	189	119	267		525																															5040
46	1436	28	206	286	116	32			44	102				129		123		29	29	175	87	147	101	85	90	87	336	578	396	907																														5554
51	2705	152	498	530	200	44							110	104		22	67		60				128	42		266	161	29	116	22	88																													5394
52	2222	152	250	861	88	176	31	87		118	29				42	139		31	2	88	81	73	129	88		632	530	921	73	156	190	433																												7622
53	1760	90	297	676	60	28			44			48		42	42								42			24	66	288	2	21	135	392	1054																											5111
54	1466	58	146	227	44						67							147	22	44		226	44				65	204			176	331	439	1321																										5027
55	1138		84	184	84		168	42	154			28	21			182			42	2		98		30	42		21		28		64			83	102																									2597
56	1638	29	44	258	290	87				44	58	42		28			44		21	44	44					160	146	161	46		447	125	478	178	245	88																								4745
57	1742	266		281	112	28								28		42				58			42	31			101	22	2	21	134	84		30	42	444	233																							3743
58	1126	168	95	389	28	84	42					42			42			42	3	21	44				30		71	28	71	42	144		71	244	102	670	1470	2000																						7069
59	1680	46	46	459		120		62	46		62	60		29	56	23		60						23		44	226		29	29	287	60	92			83	128	805	1280																					5829
61	2509	104	295	390	62	92					69	84	211			102		31		31					54		102	213	88	105	44	326	88	96	51	91	190	42	63	-																				5533
62	1840	30	272	751	78	84		46	42	112		77	44	163	84					31	64	42	28	21	23	29		44	29	63	2	248	236	1114	312	21	401	210	42	46	321																			6950
63	1206	87	220	553		354					22		29							58		29		84		29		104	29	58		52	118	612	131	58		22	44		554	786																		5239
64	1604	146	246	440		84		88			42	28			98	105			42					28	60			66			28	148	29	42	160	196	44	29	93	88	128	413	332																	4807
65	1988	42	29	224	92	56			42		166	42	126					70				58							2		75		198	48	58			21			92	266	226	238																3559
66	1558	46	46	268	232		62	124			2	112	51			56		201						88															56		209	46		209	711															4078
71	1823	105	70	788	105	116		21	21	21					56	158	44	189			149					66	56	46	225		44	132	56	104		63				46	76	98	56	103																4832
72	1958		23	1213		85			3				58	76	132	29		30	88	51	53					46		58				46	46	56				2		43	121	144	477	72	84		529													5023
73	1760	88	25	265	132		50	44	44	22		42	161			98	88	73	42			44	71		67	44		59	44	58	22	44	132	169	66	71	44			75	126	202	278	476	86	106	172	981												6391
81	3002	260	517	1125	56	439	92	48	114	51	29	63	130	184	84	157	119	28	106	221	130	75	91	170	252	226	312	76	122	98	217	311	110	29		126	166	154		76	214	254	146	28	70	174	434	515	293											11694
82	1137	44	87	533	105	332		44	88	58	29	50	44			72	44		58	158	44			92	44			114	29			22	22					86	29		100			44		46	171			405										4081
83	1318	21	261	720	195	212	60	46	44	44	44		109		29		58			44	44			140						42				48		102			21	44	88							53	58	1198	521									5514
84	1670	96	48	698		252		88			48			132	130	32			64	24		90		58	48	32	31		24		32	64					109				48	48	64	126		64	250	48		610	48	236								5312
85	1877	29	71	272	100	170	46	77	44		86		171	52	63			29	42	42			52				44		44		160		102				44		156	46	42	63		21			73	204	86	150		882	96							5936
86	2473	133	126	458	42	42						56				42		42	42				42	42								60		64			72		85		52		63				42	467	135	551		529	876	689						7225
87	2703	117		421	183	188		31	23	59	24	93				54				58	31		42		69	29		46								59						2			58		169	20	464	681	82	102	46	507	2004					8360
91	1896	293	303	1093		214	148	67	22	29	44	21	208	42		29	2				274	31	42	28		117	44			70		22	44		181		102	21	86	46	87	128	74		129		73	86	88	203	574	398	77	359	219	-				7915
92	2403		230	1102	44	387	44	108	176			29			75	202	44	29		56		2	193	22	44	147			2		28	94					29	44									130	92	58	330	344	496		1039	83	62	368			8541
93	1470	22	166	490	80	210	216	93	161		92			73	22	185		29			22		22	22	44				2		168	58					29	56				121		22			44		29	308		44	21	855	21	203	333	887		6620
Sub-Total	124449	8129	8379	24287	4900	11176	3718	6433	3947	2638	1868	3752	5088	4828	4828	4219	1978	2456	2180	4749	2172	4520	3690	1947	1095	3247	4228	3096	1928	1692	2485	3052	3315	4258	1450	2072	3061	3492	1955	510	2208	2571	1716	1339	1138	390	2087	2466	1211	4436	1569	2687	1116	3449	2327	265	701	887		319830

I. *Total People, 1959:* Intersubsector Trips for a 12 hour weekday (6.30 a.m.-6.30 p.m.) *without* adjustment for 10 percent Transverse Screen Line deficiency.

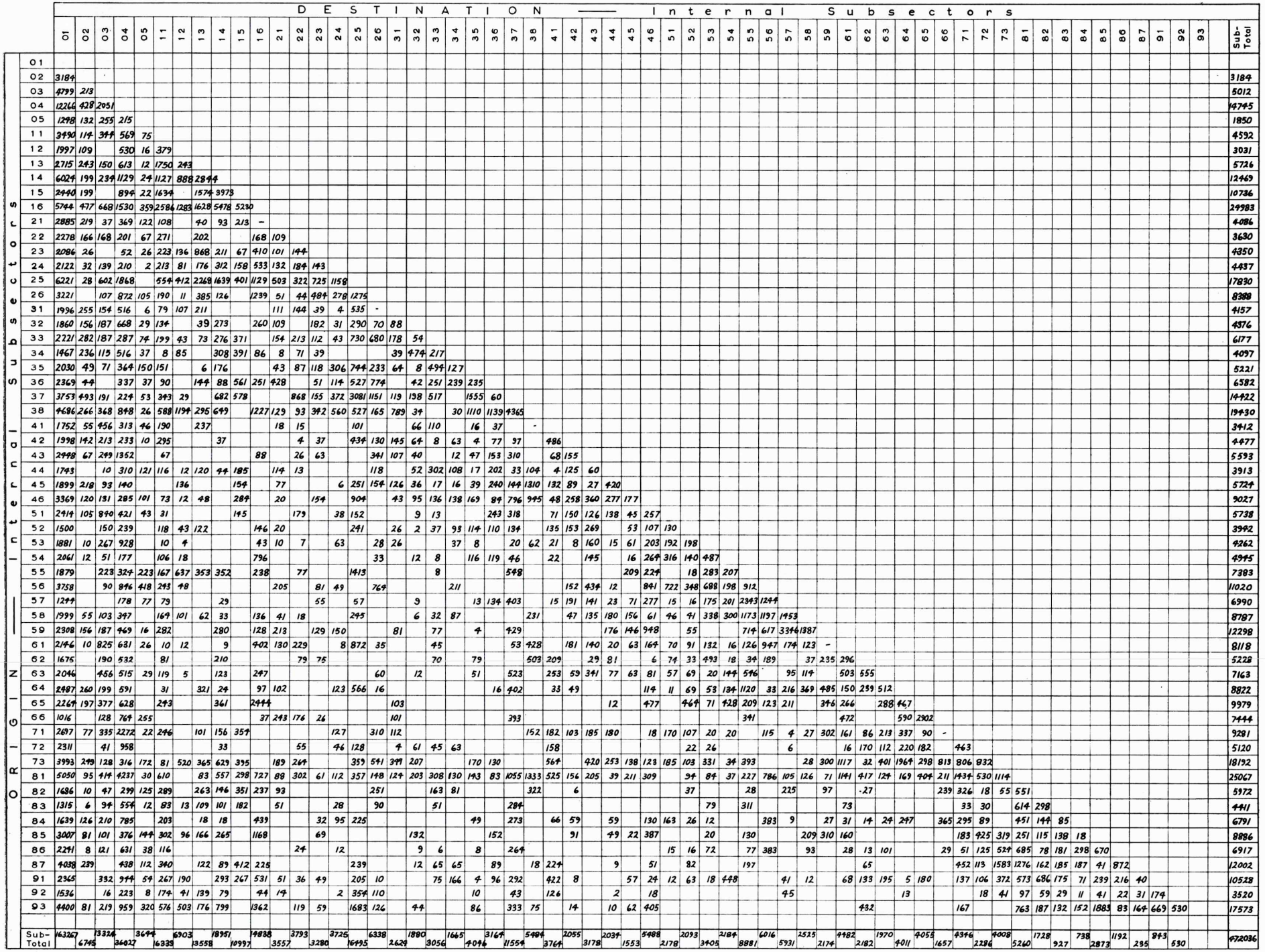


J. *Total People, 1980:* Intersubsector Trips for a 12 hour weekday (6.30 a.m.-6.30 p.m.) *without* adjustment for 10 percent Transverse Screen Line deficiency or vehicle ownership increase.

TABLE 53—*continued*



K. *Total Vehicles, 1959:* Intersubsector Trips for a 24 hour weekday *with* adjustment for 10 percent Transverse Screen Line deficiency.



L. *Total Vehicles, 1980:* Intersubsector Trips for a 24 hour weekday *with* adjustment for 10 percent Transverse Screen Line deficiency and vehicle ownership increase.

Origin (Internal Subsectors)	001	002	003	004	005	006	007	008	009	101	102	103	104	105	106	107	108	109	301	302	303	304	305	306	307	308	309	401	402	403	404	405	406	407	408	409	501	601	602	801	802	901	902	903	904	905	Sub-Total	Grand Total
01	267	318	129	288	16	119	13	42	20	219	315	367	170	123	125	132	84	7	145	895	160	449	116	166	69	32	48	289	154	28	11	391	173	94	26	264	66	400	48	194		767	304	78	41	83		8245
02		15								3	5	5	9		3				8	13	4	11	3			8		3	3			11				11	3	4		5		24	3					154
03	5						3	3		22	4	5	5	3					3	21	5	13					4	12								12	3	21		3		9	9			3		168
04	8	11		3	1			3		46	17	16	12	8	17	3	7		22	45	8	26	3	3	3	3		11	8			28		3			4	32		16		59	12	1				439
05	3	20	3	7		7				12	17	15	8	3	4		3		4	25	3	18	5	5		3		3		3		8	3	3		24	3	7		3		20	16		4	3		265
11	45	66	77	125		20	7	4	3	117	107	147	70	30	37	13	11		45	153	28	73	24	34	11	5	8	29	70	8	5	88	16	11	3	18	24	37		29		174	66	5	21	34		1898
12	7	24	9	3		3					8	4	16		3	1		3		8	5	17		7			3	11				7	4		4			3				33	3					186
13	74	18	3	9				3		25	18	8	112	8					77	53	20	18	5				3	38	8			15	7	3		18		34		5		59	7	3				651
14	81	17		9	3			4	3	67	74		15	4	3				8	24	9	3	12	8			3	36	3			3		4	5	8	3			3		42	17			8		479
15	53	45	24	3						3	3		120	44	24	9	4		3	11		8						34				4				5						16	3					416
16	309	182	38	16	8	8				92	51	18	132	44	21	15			21	78	20	40	13	13				37				41				24	4	13		40		239	8	3		3		1531
21	3	3						3			9			4			3		5	28			7					3						5		3	3	9				34	3			3		128
22		TRANSFERED				TO	21																																									
23	20	8		9	3	9				5	12	3	15	5	5		3		65	81	11	22	5	3			8	8				34	3	3		21		15		3		36	15			3		433
24	11			3	3	9					8	3	8	3					61	106		7	5	8				74								21	3	5		11		55	3					407
25	12	28		4			3	5		3	9	12	21	5	3	3			172	77	5	34	5				3	55	3			7	4			13		3				37	11					537
26						TO	24																																									
31						TO	33																																									
32	18	3		3						3	9		25	3	4	4				44	15	28	5	12			3	30	3			13		5		33	5	21	1	11		41		3				345
33	3	15	3	17		8			3	8	16		18	3	7	4			9	133	9	29	13	11				36	5	3		18		11		45		33	1	8		13	3			3		488
34						TO	32																																									
35	17	11	3	8	4	7		1	3	8	4	5	12	4	4	8	3	1	180	546	88	82	28	5	5	7		106	3		3	21	17	3		82	15	24	12	5		34	9			8		1386
36						TO	35																																									
37						7					1					1			41	26		8						41								8		7					1		4			145
38		1		4									1			3			11	148	5	17	3					45				8				16		11										273
41		3								3					3		3			21	5	20	4	3		3		30				5		4		24		3				3				3		140
42						TO	41																																									
43			3										3							30	15	3	3				3	7				3		3		30		7										110
44	3	11	3		3					11	16	3	42			5			5	176	55	58	8	4		5	7	131	18			26	8	5		95	13	5				17				3		736
45	3		1			3							5				1			17	4	3						24				4				24						3						92
46			3				3				3	4							8	77	49	21				4		63	12			9		7		96		3				5				29		396
51						TO	53																																									
52	3			3		3									4					18	8	5						15				5		3		13		8				3	3					94
53	5	9	3	8		3				5	15			3		8			3	67	17	15	5	5				22	3			7		3		46		26	5	13		67	8					371
54																																																
55			3								5		4						120	24	5	15						3				9	4	3		25	15		13	3	1	8	7					267
56												3								37	20	11						11	3			12	3	4		26		8	25	5		15		3				186
57	4	5		9	1	5						4	15	3	7	1			3	59	26	15	4		1			18				3	4	5		78	1	9		16		86		3				385
58		3				3					8								5	38	22	12				1		24				8	3			40	1	12		3		18						201
59	5	8											8							73	4	22		1	1		1	4	1	3			3	7		88		1										230
61		4																			5	15													1													25
62	8	24	4	8						5	3									8	3	3						3								12		13		3		11	3	4				115
63						TO	62																																									
64		5								28	9	21	8			3	3			40	11	15		5				8	7			11	3	3		29		42		7		29	9					296
65											12						3		8	3		3						9	7							11	3	41		3		4						107
66		5																		15		8	3									5				4		194	42			7						283
71																	5			13	3		3					16	3							4		3				4	3					57
72				12		3		3			5	3	3		8				11	34	7	17		3				3				9	3	4	7	40		44		13		30	4			3		269
73																4				3	4		4					5				4				3						3						30
81	5	20		7	1					11	4	3			3	5			4	53	5	16	11					8	3			9				11		9		8		81	8			7		292
82	5			8		3				8	17			4			3		12	9		4		5								3				3		4	5	5		40	8					146
83								3																				3				3				4				3		26						42
84						TO	81																																									
85						TO	87																																									
86	3										4								15	5		7						3	3				3			16		5				26	4					94
87	5		3	5						1	26	1	15		3				40	26	8	12	3	3		5	3	13	3			3	5	3		15	5			13		102	3					324
91	24	61	8	15	3	4	3			21	42	40	5	11	3	7	3			30	8	16	3					17	3			16	3	4		11	3	3		26		148	41	5	12	3		602
92	11	4	4	16		3			3	3	3	4								32	11	13	8	5		4		8	3			8	3		3	22		8		26		147	16	3	3			374
93	21	3				2				11	3		15				3			34	7											3				3	4	3		29		165	15					321
Sub-Total	1041	950	324	602	46	229	32	74	35	740	862	694	892	315	291	229	142	11	1114	3457	697	1282	311	309	90	80	97	1349	329	45	19	862	272	203	49	1399	181	1130	152	512	1	2740	625	111	85	189		25159

M. *Total Vehicles, 1959:* External-Internal Trips for a 24 hour weekday *with* adjustment for 10 percent Transverse Screen Line deficiency.

ORIGIN: Subsectors of Internal Zones	DESTINATION: 001	002	003	004	005	006	007	008	009	101	102	103	104	105	106	107	108	109	301	302	303	304	305	306	307	308	309	401	402	403	404	405	406	407	408	409	501	601	602	801	802	901	902	903	904	905	Sub-Total	Grand Total
01	427	479	256	604	43	236	57	77	29	552	556	665	409	196	174	212	171	29	414	2090	293	1961	251	289	138	66	103	672	218	45	29	989	337	227	44	346	123	1025	123	410	-	2671	611	166	92	145		18500
02		14						7		2	6	6	13		8				16	28	7	22	7			15		4	6			22				28	4	19		8		28	4					274
03	8						6	6		44	6	11	12	4					6	47	12	28					7	30							16	4	70		4		26	13			4		364
04	10	9		4	2			6		79	19	30	21	8	31	8	12		47	87	16	68	6	4	6	6		25	17			50		5			4	363		23		466	15	4				1449
05	2	18	4	10		12				16	18	17	12	5	10		6		8	46	4	38	12	12		6		6		6		10	4	5		27	4	34		4		44	18		6	4		428
11	42	55	123	207		37		10	8	167	122	204	10	24	79	27	19		88	257	40	149	48	71	20	10	13	52	119	14	21	130	31	14	10	21	30	249		26		450	73	4	33	58		3256
12	6	15	14	5		4				8	5	17		5	2			5		5	2	34		11			5	11				8	7		7			4				58	2					240
13	133	30	4	14				6		68	41	16	301	11					289	193	54	73	23				4	129	23			40	11	2		40		264		9		242	13					2033
14	211	40		15	4				5	252	167		51	7	8				51	81	29	18	61	12			6	169	12			7		7	15	21	4	37		8		304	43			17		1662
15	177	138	39	4						10	8		575	124	52	25	6		18	56		56						218				16				16		37				323	8					1906
16	1159	593	63	25	12	14				517	238	88	679	131	47	35			197	441	80	270	125	31				244				215				105	11	249		132		1694	30	4		4		7433
21	2	2						6			10			4			5		10	59			14					6						6		29	4	47				85	4			4		297
22																																															-
23	22	10		14	4	16				10	18	4	29	6	12		6		168	214	22	56	16	4			14	21				62	4			30		100		4		96	21			4		987
24	10			4	4	16					8	4	12	2					103	174		14	12	16				120						2		19	4	24		10		127	4					689
25	34	94		7				12		18	33	50	98	12	5	8			1046	468	26	228	39				6	318	12			29	8			49		4				262	44					2910
26																																															-
31																																															-
32	14	2		4						4	8		22	2	10	7				82	21	50	12	27			4	49	2			16		6		30	6	78	2	8		114						580
33	2	10	4	29		14			8	8	14		18	2	16	7			11	220	12	51	23	25				51	8	2		22		12		40		97	2	6		25	2			4		745
34																																															-
35	14	6	4	12	8	12		2	4	8	4	6	11	4	10	20	6		304	911	106	143	53	12	11	12		141	2		4	25	34	4		72	11	108	14	2		101	8			15		2224
36																																															-
37						12					6					2			241	147		62						213								28		75					4		6			796
38		4		8									7			8			80	1089	30	144	23					321				47				75		130										1966
41		2								4					8		6			53	12	53	7	4		6		67				10		6		32		17				6				4		297
42																																															-
43			4										5							85	34	10	8				4	15				6		2		49		49				12						283
44	2	7	4		4					14	16	4	40			12			5	319	78	121	18	7		10	12	231	31			38	16	6		106	18	28				39				4		1190
45	4		2			4							8							39	6	70						52				7				32						10						234
46			4									7							33	247	97	83				8		224	32			17		8		194		28				31				59		1072
51																																															-
52	2			4		4									10					30	12	10						23				6		2		10		21				12	2					148
53	6	6	4	12		4				8	16			2		17			2	154	29	31	14	12				45	6			10		2		50		147	8	5		93	8					691
54																																															-
55			4								16		16						488	117	22	80						12				37	7	4		82	44	34	20	8		76	22	4				1093
56												6								162	78	54						50	10			43	4	6		79		100	40	11		99						742
57	8	5		14	2	10						7	27	4	16	2			12	222	76	62	18		2			62				8	10	6		184	4	75		16		289						1141
58		4				4				14									9	107	51	43				2		65				17	4			68	2	98		4		80						572
59	12	18											29							350	11	126		2	2		2	18	5	12			4	11		245		19										866
61		5																			7	32													2		39										85
62	7	21	7	12						8	4									12	4	57						6								12		52		2		28	4	5				241
63																																															-
64		4								70	14	39	21			8	4			121	12	52		8				27	21			29	4	4		59		343		12		69	21					942
65											42						4		62	23		23						51	38							45	9	135		7		27						466
66		9																		66		38	12									16				8		374	58			36						617
71																	8			18	6		8					38	6							5		58				16	4					167
72				21		4		6			8	4	4		17				29	68	5	45						6				18	4	7	17	55		230		12		50				4		618
73																10				16	16		23					25				14						67				39						210
81	6	22		10	4					18	6	4			8	12			10	110	10	40	27					22	5			17				14		305		14		170	10			14		858
82	8			12		4				14	27			4			4		33	23		10		4								16				2		26	8	6		151	11					363
83								6																				6				4				4				4		74						98
84																																															-
85																																															-
86	2										6								25	8		11						6	4				4			12		15				53	4					150
87	8		4	8						2	47	2	33		8				99	81	21	43	8	4		8	4	37	8			6	12	2		27	10			21		477	4					984
91	23	55	12	23	4	8	5			31	51	62	8	9	5	12	5			62	11	39	6					34	5			27	4	6		12	4	10		30		385	49	4	16	4		1021
92	8	2	5	27		4			6	2	2	4								48	14	23	14	8		8		13	2			10	4		8	18		27		21		311	14		4			607
93	61	8				4				43	8		62				4			204	28										10				8	14	4		83		917	48					1506
Sub-Total	2430	1687	561	1109	91	423	68	144	60	1969	1567	1245	2641	561	539	434	266	34	3904	9390	1394	4119	888	563	179	157	184	3935	592	79	54	2054	513	362	103	2404	314	5315	275	910		10666	1122	191	157	348		66001

N. *Total Vehicles, 1980:* External-Internal Trips for a 24 hour weekday *with* adjustment for 10 percent Transverse Screen Line deficiency and vehicle ownership increase.

TABLE 54

TRAFFIC, HOUSEHOLDS, AND EMPLOYMENT IN THE INTERNAL AREA, 1959 AND 1980: BY SUBSECTORS

SUBSECTOR	TRAFFIC[1]				HOUSEHOLDS		TOTAL EMPLOYMENT	
	1959		*1980*		*1959*	*1980*[2]	*1959*	*1980*[2]
	External Part	*Total*[3]	*External Part*	*Total*[3]				
11	1,898	15,505	3,256	24,187	1,010	1,076	3,007	4,020
12	186	5,753	240	10,174	967	1,207	347	594
13	651	7,328	2,033	21,317	988	1,363	471	2,388
14	479	8,886	1,662	33,082	1,043	3,971	1,286	2,262
15	416	4,215	1,906	23,639	1,044	2,771	223	2,221
16	1,531	7,247	7,433	47,254	985	2,635	2,254	6,310
21	128	5,360	297	7,940	1,011	1,204	198	222
22	—	5,836	—	7,423	912	1,067	189	250
23	433	7,033	987	8,617	1,028	1,185	154	199
24	407	5,596	689	8,851	1,037	1,265	245	378
25	537	7,143	2,910	37,235	1,083	3,560	928	2,320
26	—	3,883	—	14,726	995	1,877	94	565
31	—	5,026	—	6,781	974	940	213	265
32	345	4,866	580	6,836	994	904	260	278
33	488	8,355	745	9,978	986	962	477	644
34	—	4,143	—	5,762	1,022	949	127	141
35	1,386	8,217	2,224	11,491	970	1,030	498	605
36	—	5,121	—	9,746	938	1,051	528	564
37	145	5,036	796	26,772	950	2,740	144	1,128
38	273	4,108	1,966	26,880	1,019	3,434	543	1,730
41	140	3,494	297	7,473	954	980	251	328
42	—	4,551	—	6,532	987	962	259	340
43	110	3,639	283	9,054	882	1,544	162	199
44	736	3,963	1,190	7,137	1,005	1,054	172	180
45	92	3,953	234	7,511	1,043	1,221	166	240
46	396	6,322	1,072	15,587	1,008	2,516	186	270
51	—	4,041	—	7,916	893	788	485	965
52	94	4,034	148	6,183	1,008	1,085	172	177
53	371	4,748	691	8,358	929	996	369	510
54	—	3,144	—	7,129	960	1,278	71	126
55	267	3,358	1,093	17,357	776	1,693	169	2,030
56	186	3,988	742	17,778	1,009	2,353	387	974
57	385	4,829	1,141	14,062	960	1,248	552	754
58	201	4,175	572	11,884	969	2,067	162	215
59	230	3,970	866	15,338	989	2,706	264	395
61	25	5,637	85	12,685	914	812	857	2,275
62	115	3,393	241	7,651	955	942	651	712
63	—	3,272	—	9,133	904	1,289	417	469
64	296	4,912	942	13,775	919	1,851	607	530
65	107	2,664	466	14,500	820	2,808	111	194
66	283	2,430	617	9,718	878	1,395	279	315

TABLE 54—*continued*

SUBSECTOR	TRAFFIC[1]				HOUSEHOLDS		TOTAL EMPLOYMENT	
	1959		*1980*		*1959*	*1980*[2]	*1959*	*1980*[2]
	External Part	*Total*[3]	*External Part*	*Total*[3]				
71	57	5,994	167	13,794	898	940	1,331	2,378
72	269	5,695	618	8,024	927	1,350	112	92
73	30	4,935	210	22,410	883	1,458	1,496	3,960
81	292	15,111	858	31,185	774	656	2,946	5,080
82	146	3,746	363	8,063	946	980	278	631
83	42	3,386	98	5,436	977	1,040	98	125
84	—	3,665	—	7,529	961	920	294	352
85	—	3,777	—	11,759	919	2,030	146	238
86	94	4,730	150	8,259	1,018	1,210	162	206
87	324	5,452	984	13,221	955	2,051	247	383
91	602	6,614	1,021	12,392	1,008	960	1,131	1,720
92	374	4,838	607	4,657	949	1,064	75	103
93	321	4,709	1,506	19,079	960	2,842	531	839
Subtotal ..	15,888	285,826	44,986	741,260	51,893	84,280	27,782	55,389
01	8,245	88,005	18,500	181,767	1,244	3,000[4]	29,273	40,900
02	154	6,080	274	10,203	766		831	1,189
03	168	8,984	364	18,700	654		1,720	2,820
04	439	27,202	1,449	52,221	355		8,521	12,005
05	265	3,935	428	5,922	—		1,438	1,697
Subtotal ..	9,270	134,206	21,015	268,813	3,019	3,000	41,783	58,611
TOTAL ..	25,158	420,032	66,001	1,010,073	54,912	87,280	69,565	114,000

[1] Trip ends (arrivals and departures of private cars, taxis and trade vehicles) for each subsector, excluding trips passing through without stopping; adjusted for 24 hour volumes, 10 per cent Transverse Screen Line deficiency, car ownership growth factor of 1.43 and trade vehicle ownership growth factor of 1.33.

[2] Estimated, see Chapter Four.

[3] Total number of trip ends, being twice the number of internal trips (since origin and destination are both in the Internal Area) and the actual number of external trips (since only one end is in the Internal Area).

[4] Although no overall change in the number of households in Sector 0 is expected, there will be a redistribution among the subsectors of Sector 0.

TABLE 55

EXTERNAL TRAFFIC ASSOCIATED WITH THE INTERNAL AREA, 1959 AND 1980: BY LOCALITIES

LOCALITY NUMBER AND PLACE	EXTERNAL TRAFFIC[1] ASSOCIATED WITH INTERNAL AREA				
	1959		*1980*		
	Through Internal Area[2]	*Total*[3]	*Total*[3]	*Through Internal Area*[2]	*To Belts*
BELFAST/MARSHLAND AND NORTHWARDS					
North of Ashley River					
306 Amberley	1	310	565	2	
307 Cheviot	4	94	191	12	
308 Kaikoura	1	81	161	4	
309 North of Kaikoura	7	104	200	16	
406 Waipara	12	284	535	22	
407 Culverden	11	214	382	20	
408 West Coast (via Lewis Pass) ..	5	54	113	10	
	41	1,141	2,147	86	
Ashley River to Waimakariri River					
304 Kaiapoi	34	1,266	4,222	103	
305 Woodend	11	322	919	31	
402 Cust/Oxford	11	340	614	22	
403 Ohoka	—	45	79	—	
404 Tuahiwi	—	19	54	—	
405 Rangiora	12	874	2,077	23	
501 Eyreton	1	182	316	2	
	69	3,048	8,281	181	
Waimakariri River to Internal Area					
302 Belfast	65	3,522	9,557	167	
303 Chaneys/Kainga	30	727	1,455	61	
401 Marshland, etc.	12	1,361	3,970	35	
	107	5,610	14,982	263	
Subtotal	217	9,799	25,410	530	11,200
YALDHURST AND WESTWARDS					
104 Yaldhurst	32	924	2,722	81	
105 West Melton	7	322	575	14	
106 Darfield	8	299	555	16	
107 Glentunnel	11	240	457	23	
108 Sheffield	5	147	279	13	
109 West Coast (via Arthur's Pass) ..	1	12	36	2	
	64	1,944	4,624	149	
Subtotal	64	1,944	4,624	149	1,700
TEMPLETON AND SOUTHWARDS					
001 Templeton	30	1,071	2,512	82	
002 Burnham	29	979	1,748	61	
003 Rakaia/Methven	3	327	565	4	
004 Ashburton	13	615	1,141	32	
005 Geraldine	7	53	105	14	
006 Timaru	25	254	481	58	
007 Oamaru	—	32	68	—	
008 Dunedin	9	83	171	27	
009 South of Dunedin	8	43	85	25	
	124	3,457	6,876	303	
Subtotal	124	3,457	6,876	303	2,850

TABLE 55—*continued*

LOCALITY NUMBER AND PLACE	EXTERNAL TRAFFIC[1] ASSOCIATED WITH INTERNAL AREA				
	1959		*1980*		
	Through Internal Area[2]	*Total*[3]	*Total*[3]	*Through Internal Area*[2]	*To Belts*
PREBBLETON AND SPRINGS/ELLESMERE					
101 Prebbleton	18	758	2,026	57	
102 Lincoln	24	886	1,623	56	
103 Leeston	28	722	1,298	53	
	70	2,366	4,947	166	
Subtotal	70	2,366	4,947	166	2,450
HALSWELL/AKAROA					
901 Halswell	82	2,822	10,911	245	
902 Taitapu	16	641	1,157	35	
903 Motukarara	1	112	193	2	
904 Little River	4	89	165	8	
905 Akaroa	12	211	377	29	
	115	3,875	12,803	319	
Subtotal	115	3,875	12,803	319	5,600
MISCELLANEOUS					
301 Harewood	18	1,132	3,959	55	
409 Burwood	25	1,424	2,453	49	
601 Lyttelton	67	1,197	5,514	199	
602 Godley Head	3	155	281	6	
801, 802 Governors Bay and Diamond Harbour	3	516	916	6	
	116	4,424	13,123	315	
Subtotal	116	4,424	13,123	315	5,050[4]
TOTAL EXTERNAL TRAFFIC	706	25,865	67,783	1,782	28,850

[1] Trip ends, (arrivals and departures of private cars, taxis and trade vehicles) for each external locality, of trips to, from and through the Internal Area; adjusted for 24 hour volumes, 10 per cent Transverse Screen Line deficiency, car ownership growth factor of 1.55 and trade vehicle ownership growth factor of 1.33.

[2] Total number of trip ends, being twice the number of trips since each trip has both ends in an external locality.

[3] Total number of trip ends, being the actual number of internal trips (since only one end is in the external locality) and twice the number of through trips (since origin and destination are both in an external locality).

[4] Major contributors to 1980 traffic to the Belts are Harewood (1150); Lyttelton Road Tunnel (3400); Governors Bay (500). No Burwood traffic is assigned to the Belts.

TABLE 56

1980 TRAFFIC: EVALUATION OF PROBLEMS ON THE RADIALS AND ON THE BELTS

A. ON THE RADIALS

CATCHMENT AREA	*Rate of Urban Development Relative to Capacity Within Urban Fence*[1]	*Potential for Urban Development beyond Urban Fence*[2]	*Radials Within the Catchment Area*	*Expected 1980 Traffic Volume Relative to "1980" Traffic Assignment*[3]	*Section of Radial for Individual Consideration*	*Situation on Section of Radial "as is" in 1980 (deduced from Col. 5)*[4]	*Situation on Section of Radial "as is" beyond 1980 (deduced from Cols. 5 and 3)*[4]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Creyke Rd.-Kilmarnock St.	Before 1980	considerable	1.1 Kilmarnock St.-Creyke Rd.-Annandale St.	appreciably above assignment	1.1.1 Deans Ave. to Clyde Rd.	satisfactory, if alignment improved	satisfactory, if alignment improved
					1.1.2 West of Clyde Rd.	satisfactory	satisfactory
2. Memorial Ave.-Fendalton Rd.	Before 1980	considerable	2.1 Fendalton Rd.-Memorial Ave.	appreciably above assignment	2.1.1 Harper Ave. to Otara St.	seriously overloaded*	very seriously overloaded*
						*Does not take account of the widening provided for in the Waimairi County District Scheme.	
3. Wairakei Rd.-Rossall St.	Before 1980	appreciable	3.1 Carlton Mill Rd.-Rossall St.-Wairakei Rd.	somewhat above assignment	3.1.1 Bealey Ave. to Idris Rd.	overloaded, in parts seriously overloaded	seriously overloaded
					3.1.2 Idris Rd. to Greers Rd.	satisfactory	overloaded
4. Harewood Rd.-Papanui Rd.	Before 1980	appreciable	4.1 Papanui Rd.-Harewood Rd.	somewhat above assignment	4.1.1 Bealey Ave. to Papanui	very seriously overloaded	***
					4.1.2 Papanui to Greers Rd.	overloaded	very seriously overloaded
5. Main North Rd.-Cranford St.	Before 1980	very considerable	5.1 Springfield Rd.-Rutland St.	same as assignment	5.1.1 the whole length	satisfactory	satisfactory
			5.2 Cranford St.-Main North Rd.	considerably above assignment	5.2.1. Bealey Ave. to Winters Road	very seriously overloaded	***
					5.2.2 Winters Road to Styx Overbridge	***†	***†
					5.2.3 Styx Overbridge to Chaneys	satisfactory†	very seriously overloaded†
						†Does not take account of the widening provided for in the Waimairi County District Scheme.	
6. Madras St.-Barbadoes St.	By 1980	very little	6.1 Various	same as assignment	6.1.1 the whole length	satisfactory	satisfactory
7. Hills Rd.-Marshland Rd.	By 1980	appreciable	7.1 Whitmore St.-Hills Rd.	same as assignment	7.1.1 Bealey Ave. to North Avon Rd. (Whitmore St. and part Hills Rd.)	overloaded	very seriously overloaded
					7.1.2 northwards from North Avon Rd.	satisfactory	satisfactory
			7.2 North Avon Rd.-Marshland Rd.	same as assignment	7.2.1 Hills Rd. to New Brighton Rd.	satisfactory, if alignment improved	slightly overloaded, if alignment improved
8. Eastern Suburbs (Wainoni Rd. round to Ferry Rd.)	After 1980	appreciable	8.1 Various:— Avonside Dr. to Tuam St. incl. Wainoni Rd. Pages Rd. and Linwood Ave.	appreciably below assignment	8.1.1 the whole length	satisfactory	satisfactory except for some overloading in Kerrs Rd.-Pages Rd.-Woodham Rd. area
			8.2 Ferry Rd.-Main Rd. to Sumner	considerably below assignment	8.2.1 Wilsons Rd. to Aldwins-Ensors Rd.	seriously overloaded	***
					8.2.2 Aldwins Rd.-Ensors Rd. to Radley St.	overloaded	***

					8.2.3 Radley St. to Tunnel Rd.	satisfactory	seriously overloaded
					8.2.4 Tunnel Rd. to Humphreys Drive	satisfactory	overloaded
					8.2.5 Humphreys Drive to McCormacks Bay	slightly overloaded	very seriously overloaded
					8.2.6 McCormacks Bay to Moncks Bay	satisfactory	slightly overloaded
9. Opawa Rd.-Waltham Rd.	By 1980	appreciable	9.1 Opawa Rd.-Port Hills Rd.	same as assignment	9.1.1 Waltham Rd. to Ensors Rd.	slightly overloaded	seriously overloaded
					9.1.2 Ensors Rd. to Garlands Rd.	satisfactory	overloaded
			9.2 Waltham Rd.	same as assignment	9.2.1 Moorhouse Ave. to Shakespeare Rd.	seriously overloaded	***
					9.2.2 South of Shakespeare Rd.	satisfactory	satisfactory
10. Colombo St.	By 1980	considerable	10.1 Colombo St.-Dyers Pass Rd.	same as assignment	10.1.1 Moorhouse Ave. to Brougham St.	***	***
					10.1.2 Brougham St. to Milton St.	seriously overloaded	***
					10.1.3 Milton St. to Tennyson St.	overloaded	very seriously overloaded
					10.1.4 Tennyson St. to Cashmere Rd.	satisfactory	overloaded
			10.2 Antigua St.-Montreal St.	same as assignment	10.2.1 the whole length	satisfactory	satisfactory
11. Halswell Rd.-Lincoln Rd.	By 1980	considerable	11.1 Lincoln Rd.-Halswell Rd.	same as assignment	11.1.1 Moorhouse Ave. to Barrington St.	very seriously overloaded	***
					11.1.2 Barrington St. to Hoon Hay Rd.	seriously overloaded	***
					11.1.3 Hoon Hay Rd. to Hendersons Rd.	slightly overloaded	very seriously overloaded
					11.1.4 Hendersons Rd. to Halswell	satisfactory	overloaded
12. Western (Blenheim Rd.-Riccarton Rd.)	After 1980	very considerable	12.1 Blenheim Rd.-Main South Rd.	appreciably below assignment	12.1.1 Blenheim Rd.	seriously overloaded	***
					12.1.2 Main South Rd. (Sockburn)	seriously overloaded	***
					12.1.3 Main South Rd. (Sockburn to Hornby)	overloaded	***
			12.2 Riccarton Rd.-Yaldhurst Rd.	same as assignment	12.2.1 Riccarton Rd. (Riccarton)	overloaded	seriously overloaded
					12.2.2 Riccarton Rd. (Upper Riccarton)	seriously overloaded	very seriously overloaded
					12.2.3 Church Corner to Avonhead Rd.	satisfactory	seriously overloaded

TABLE 56—*continued*

B. ON THE BELTS

BELT	*Rate of Urban Development Relative to Capacity Within Urban Fence*[1]	*Potential for Urban Development beyond Urban Fence*[2]	*Street Name*	*Expected 1980 Traffic Volume Relative to "1980" Traffic Assignment*[3]	*Section of Street for Individual Consideration*	*Situation on Section of Street "as is" in 1980 (deduced from Col. 5)*[4]	*Situation on Section of Street "as is" beyond 1980 (deduced from Cols. 5 and 3)*[4]
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. North Belt	Before 1980	considerable	1.1 Harper Ave.	above assignment	1.1.1 the whole length	seriously overloaded	***
			1.2 Bealey Ave.	above assignment	1.2.1 Carlton Mill Rd. to Durham St.	seriously overloaded	***
					1.2.2 Durham St. to Manchester St.	overloaded	very seriously overloaded
					1.2.3 Manchester St. to Fitzgerald Ave.	satisfactory	satisfactory
2. East Belt	After 1980	appreciable	2.1 Fitzgerald Ave.	below assignment	2.1.1 Bealey Ave. to Lichfield St.	satisfactory if single carriageway section is duplicated	satisfactory if single carriageway section is duplicated
					2.1.2 Lichfield St. to Moorhouse Ave.	satisfactory	seriously overloaded
3. South Belt	After 1980	considerable	3.1 Moorhouse Ave.	below assignment	3.1.1 Fitzgerald Ave. to Waltham Rd.	satisfactory	satisfactory
					3.1.2 Waltham Rd. to Antigua St.	very seriously overloaded with central section***	***
					3.1.3 Antigua St. to Lincoln Rd.	overloaded	***
					3.1.4 Lincoln Rd. to Deans Ave.	***	***
4. West Belt	By 1980	considerable	4.1 Deans Ave.	same as assignment	4.1.1 Moorhouse Ave. to Blenheim Rd.	***	***
					4.1.2 Blenheim Rd. to Harper Ave.	seriously overloaded	***

FOOTNOTES TO TABLE 56

[1] *Column 2*
'Rate of Urban Development relative to capacity within Urban Fence.'

This gives the expected time by which the amount of urban development that can be accommodated within the urban fence, as at present defined, is reached, whether or not this development is located all inside or partly in and partly outside the urban fence, and is expressed in general terms as 'Before', 'By', or 'After' 1980. This question arises because of the assumption used in the forecast regarding the distribution of population.

The assessment for part B of this table embraces all the Catchment Areas which contribute significantly to traffic on the Belt in question.

[2] *Column 3*
'Potential for Urban Development beyond the Urban Fence.'

This considers the likelihood of urban development beyond the urban fence, as at present defined, and its possible extent by about the year 2000, and is expressed in general terms, relative to each individual Catchment Area as 'Very Little', 'Appreciable', 'Considerable', or 'Very Considerable'.

The assessment for part B of this table embraces all the Catchment Areas which contribute significantly to traffic on the Belt in question.

[3] *Column 5*
'Expected 1980 Traffic Volume relative to "1980" Traffic Assignment.'

As a result of the questions examined for Columns 2 and 3 (see above) this gives the volume of traffic that can actually be expected in 1980 and is expressed in terms relative to the '1980' Traffic Assignment, and generally as 'Above', 'Same as', or 'Below', the '1980' Traffic Assignment.

[4] *Columns 7 and 8*
'The Situation on Section of Radial or Street, "as is" in 1980 (Column 7) and beyond 1980 (Column 8).' Each Section of the radial or street is examined and, taking the road as it is today ('as is') and assuming that feasible moderate improvements are made to intersections, it is then classified in terms of its capacity to carry the traffic. Anything below 'design' capacity is termed 'satisfactory' but anything at or above 'design' capacity is regarded as being overloaded to some extent. 'Seriously overloaded' means that the section of road has reached or is just about to reach its 'possible' capacity; in some cases it may be just over it. The symbol *** is used to denote a traffic volume which is well above the 'possible' capacity. (The traffic that can be expected in the year 1980 is deduced from Column 5 and that beyond 1980 is deduced, very approximately, from Column 3.)

N.B. (i) Moderate improvements to intersections cover widening of approaches and provision of traffic signals where necessary and, as a minimum, the removal of corner obstructions including kerbs of small radius.

(ii) 'Design' and 'Possible' Capacity refer to the maximum traffic volumes which the streets can handle measured in terms of the prevailing road conditions and the standard of service provided.

'Possible' Capacity is that traffic volume beyond which the slightest abnormal occurrence will bring traffic to a standstill. It represents low-speed travel with severe intersection delays.

'Design' Capacity. For design purposes it is recognised practice to use a lower figure than 'possible' capacity. The figure chosen is usually arrived at from considerations of the standard of service required of the given road because the nearer 'design' capacity approaches 'possible' capacity, the more frequent and lengthy do delays become with consequent increases in frustration and hazard. By way of illustration for Radials, 'design' capacity represents a level of service similar to that provided today by Riccarton Road or Papanui Road. However, in anticipation of minor improvements such as intersection treatment and parking and stopping restrictions, the 'Design' volume has been set higher than the volumes now being carried by such roads. It is not possible to give an illustration for Belts as no part of the Belts has yet reached the traffic volumes that would represent the 'Design' volume for the Belts.

TABLE 57

SUMMARY DATA FOR THE INTERNAL AREA, 1959-1980

ITEM	1959	1980	PROPORTIONATE INCREASE 1959-1980
Population	196,135	311,450	1.59
Number of Households	54,912	87,280	1.59
Employment			
Total	69,565	114,000	1.64
Industrial	28,880	48,000	1.66
Commercial	20,307	30,519	1.50
Other	20,378	35,481	1.74
Motor Vehicles Per 1,000 Population			
Total	307	461	1.50
Cars	244	380	1.55
Trade Vehicles	37	49	1.33
Remainder	26	32	1.23
Motor Vehicles			
Total	60,213	143,578	2.38
Cars	47,857	118,351	2.47
Trade Vehicles	7,257	15,261	2.10
Remainder	5,099	9,966	1.95
Traffic (Motor Vehicle Trips—24 hours)			
Total	222,593	538,037	2.42
To and from Central Traffic District	88,005	181,767	2.07
Remainder	134,588	356,270	2.65

I. IDENTIFICATION MAPS

This Appendix has three general reference maps for use throughout the book. Figure 75 identifies sub-sectors, zones and adjacent localities: Figure 76 is a generalised land use map of Christchurch: and Figure 77, which folds out, is a location map for the Christchurch area.

LOCALITIES OF THE EXTERNAL AREA

Localities adjacent to the Internal Area are identified by numbers and mapped in Figure 75; with other localities of the South Island, they are described below in relation to major roads.

Main South Road Destinations (00-)
- 001 Templeton and vicinity
- 002 Weedons–Rolleston–Burnham–Dunsandel
- 003 Rakaia–Chertsey–Methven
- 004 Ashburton and vicinity
- 005 Geraldine–Fairlie–Central Otago
- 006 Temuka–Timaru–Waimate
- 007 Oamaru–Palmerston
- 008 Dunedin and vicinity
- 009 South of Dunedin

Springs Road Destinations (10-)
- 101 Prebbleton and vicinity
- 102 Lincoln–Springston–Selwyn
- 103 Leeston–Southbridge–Rakaia

West Coast Road Destinations (10-)
- 104 Yaldhurst—Paparua
- 105 West Melton–Aylesbury–Kirwee
- 106 Darfield and vicinity
- 107 Glentunnel–Hororata–Lake Coleridge
- 108 Sheffield–Springfield–Arthur's Pass
- 109 West Coast via Arthur's Pass

Harewood (301)
- 301 Harewood and vicinity

Main North Road Destinations (30-)
- 302 Belfast
- 303 Chaneys–Kainga–Stewarts Gully
- 304 Kaiapoi
- 305 Woodend and vicinity
- 306 Amberley
- 307 Cheviot County
- 308 Kaikoura County
- 309 North of Kaikoura County

Destinations Associated with Main North Road (40-)
- 401 Marshland–Spencer Park–Brooklands
- 402 Cust–Oxford
- 403 Ohoka and vicinity
- 404 Tuahiwi and vicinity
- 405 Rangiora
- 406 Waipara County
- 407 Culverden–Hanmer
- 408 West Coast via Lewis Pass
- 409 Burwood and vicinity
- 501 Eyreton–Clarkville–Eyrewell

Lyttelton (60-)
- 601 Lyttelton and vicinity
- 602 Summit Road–Godley Head

Destinations via Dyers Pass (80-)
- 801 Governors Bay–Teddington
- 802 Diamond Harbour and vicinity

Akaroa Road Destinations (90-)
- 901 Halswell and vicinity
- 902 Ladbrooks–Greenpark–Taitapu
- 903 Motukarara–Birdlings Flat
- 904 Little River and vicinity
- 905 Duvauchelle–Akaroa–Pigeon Bay

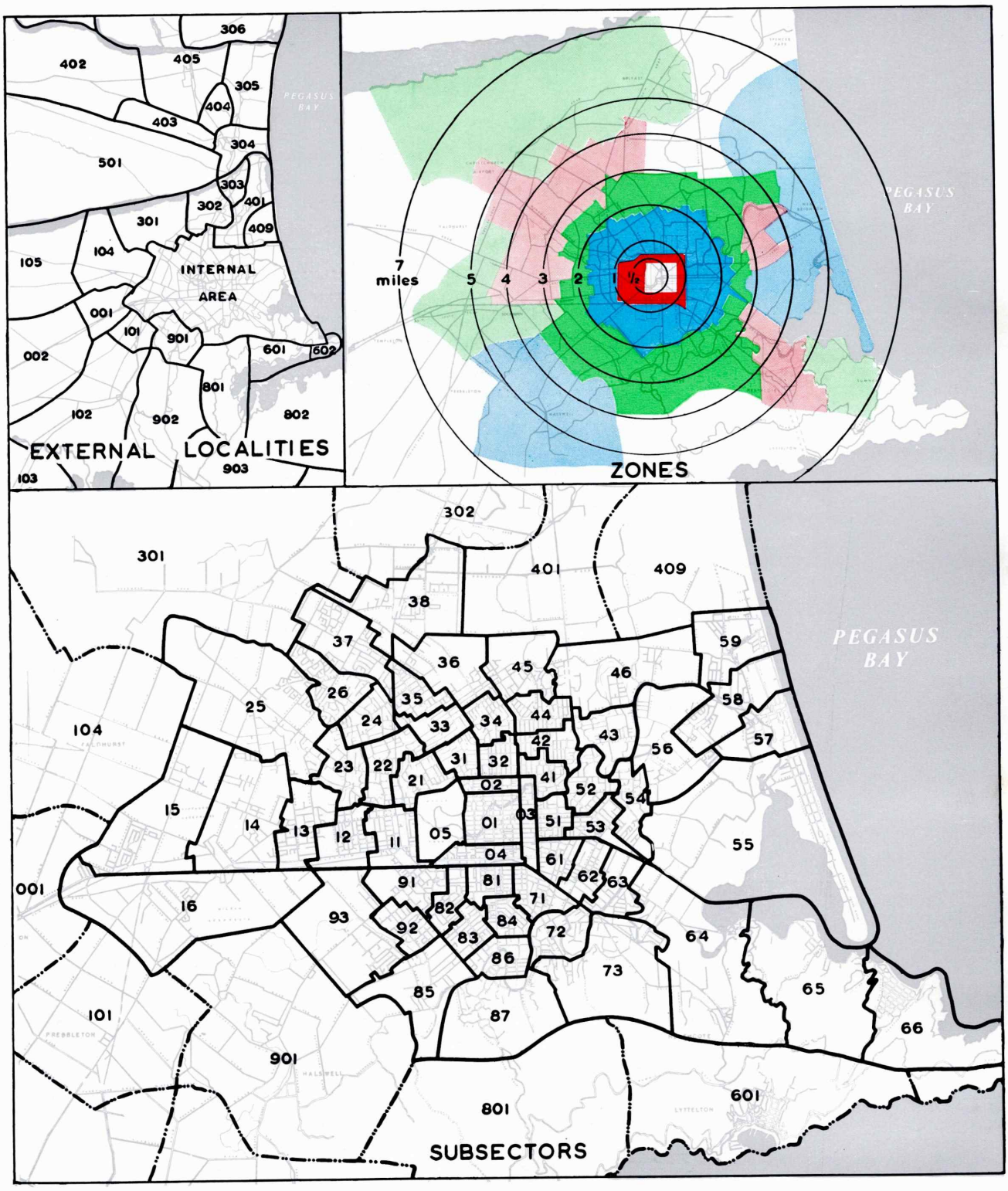


Fig. 75. IDENTIFICATION MAP: SUBSECTORS, ZONES, AND ADJACENT LOCALITIES.

Distance Zones which are shown upper right are also referred to in Fig. 40.

Zone I — Red	Zone III — Green	Zone V — Blue tone
Zone II — Blue	Zone IV — Red tone	Zone VI -- Green tone

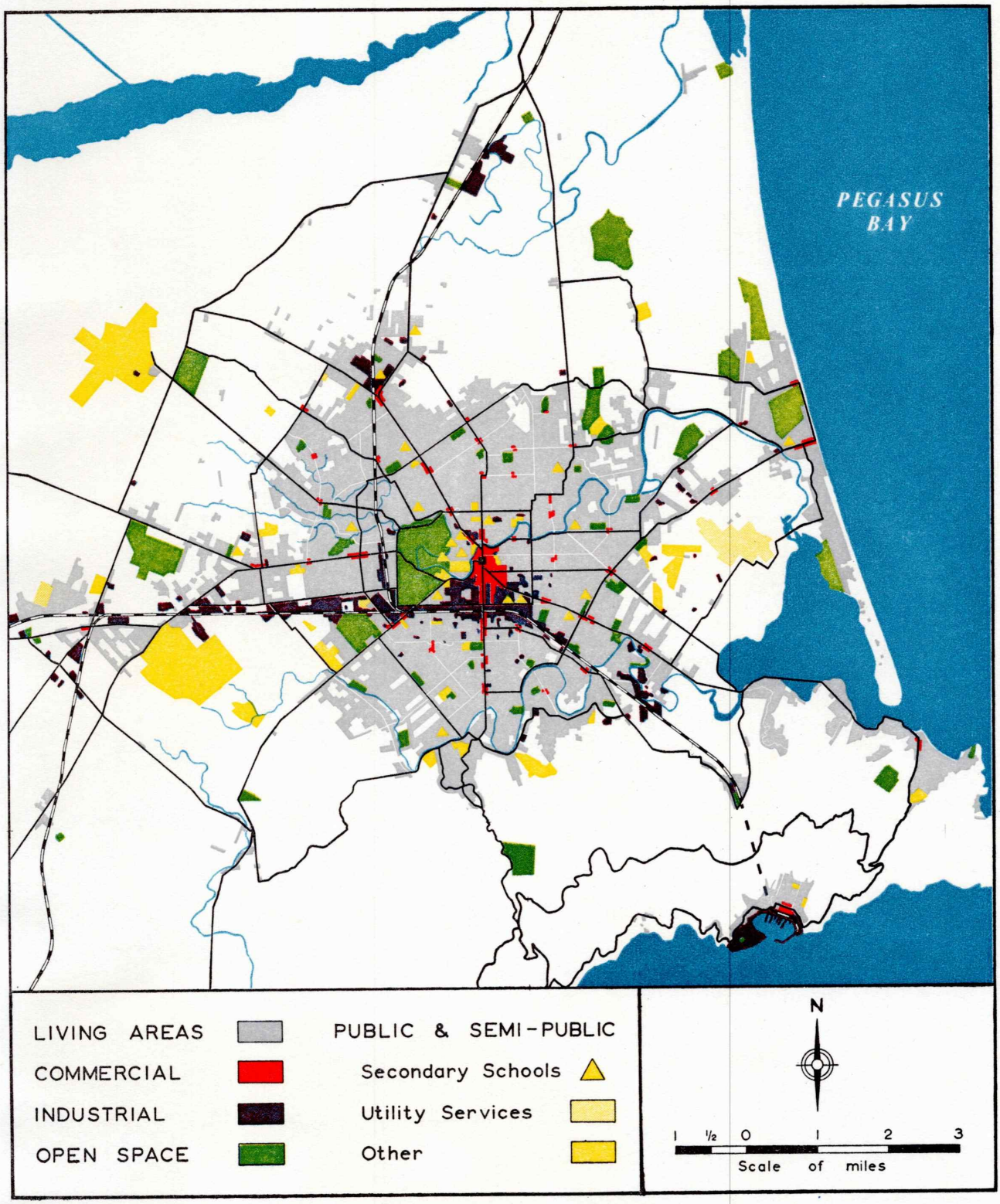


Fig. 76. IDENTIFICATION MAP: GENERALISED LAND USE IN CHRISTCHURCH, 1956.

Fig. 77. IDENTIFICATION MAP: CHRISTCHURCH AND ADJACENT AREAS
(Map reproduced from *A Descriptive Atlas of New Zealand* by permission of the Department of Lands and Survey)

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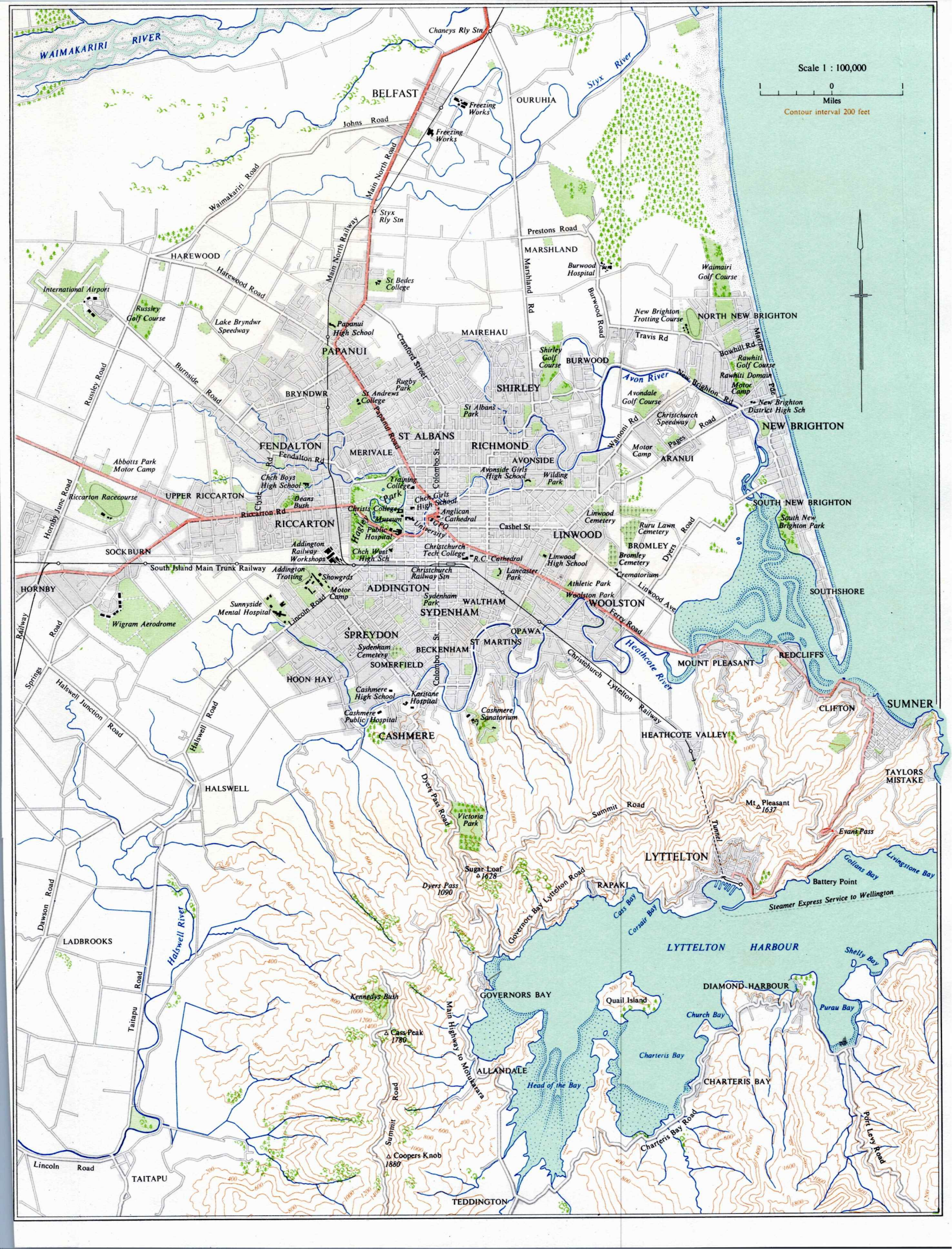
Scale 1 : 100,000
0
Miles
Contour interval 200 feet
WAIMAKARIRI RIVER
Chaneys Rly Stn
BELFAST
Freezing Works
Freezing Works
Johns Road
Waimakariri Road
Main North Road
Styx Rly Stn
Main North Railway
Styx River
OURUHIA
Prestons Road
MARSHLAND
Marshland Rd
Burwood Hospital
Waimairi Golf Course
HAREWOOD
Harewood Road
International Airport
Russley Golf Course
Lake Bryndwr Speedway
St Bedes College
Papanui High School
PAPANUI
MAIREHAU
Crawford Street
Shirley Golf Course
BURWOOD
Burwood Road
New Brighton Trotting Course
NORTH NEW BRIGHTON
Travis Rd
Bowhill Rd
Marine Pde
Rawhiti Golf Course
Rawhiti Domain
Motor Camp
Avon River
New Brighton Rd
Avondale Golf Course
New Brighton District High Sch
Christchurch Speedway
Road
NEW BRIGHTON
Russley Road
Burnside Road
BRYNDWR
Rugby Park
St Andrews College
SHIRLEY
St Albans Park
Papanui Road
Waltoni Rd
Motor Camp
Pages
ARANUI
FENDALTON
Fendalton Rd
MERIVALE
ST ALBANS
RICHMOND
AVONSIDE
Avonside Girls High School
Wilding Park
Abbotts Park Motor Camp
Hornby Junc Road
Riccarton Racecourse
UPPER RICCARTON
Chch Boys High School
Deans Bush
Clyde Rd
Riccarton Rd
Training College
Park
Chch Girls High School
Colombo St
Christs College
Museum
Anglican Cathedral
GPO
University
Hagley Park
Public Hospital
RICCARTON
Cashel St
LINWOOD
Linwood Cemetery
Ruru Lawn Cemetery
Road
BROMLEY
Dyers
Bromley Cemetery
Crematorium
SOUTH NEW BRIGHTON
South New Brighton Park
SOCKBURN
Addington Railway Workshops
Chch West High Sch
Christchurch Tech College
R.C. Cathedral
Linwood High School
South Island Main Trunk Railway
Addington Trotting
Showgrds
Motor Camp
Christchurch Railway Stn
Lancaster Park
Athletic Park
Woolston Park
WOOLSTON
Linwood Ave
HORNBY
ADDINGTON
Sydenham Park
WALTHAM
SYDENHAM
Sunnyside Mental Hospital
Lincoln Road
Wigram Aerodrome
Railway
Road
Springs
Ferry Road
SOUTHSHORE
SPREYDON
OPAWA
ST MARTINS
Sydenham Cemetery
BECKENHAM
Colombo St
SOMERFIELD
HOON HAY
Heathcote River
MOUNT PLEASANT
REDCLIFFS
Christchurch Lyttelton Railway
Cashmere High School
Karitane Hospital
Cashmere Public Hospital
Cashmere Sanatorium
CLIFTON
SUMNER
CASHMERE
HEATHCOTE VALLEY
Halswell Junction Road
Halswell Road
HALSWELL
Dyers Pass Road
Victoria Park
Summit Road
Mt Pleasant 1637
TAYLORS MISTAKE
Tunnel
Evans Pass
LYTTELTON
Sugar Loaf 1628
Dyers Pass 1090
Governors Bay Lyttelton Road
RAPAKI
Gollans Bay
Livingstone Bay
Battery Point
Steamer Express Service to Wellington
Cass Bay
Corsair Bay
Dawson Road
LADBROOKS
Halswell River
LYTTELTON HARBOUR
Shelly Bay
DIAMOND HARBOUR
Purau Bay
Church Bay
Quail Island
GOVERNORS BAY
Kennedys Bush
Cass Peak 1780
Main Highway to Moutuara
Charteris Bay
ALLANDALE
Head of the Bay
CHARTERIS BAY
Taitapu Road
Summit Road
Coopers Knob 1880
Charteris Bay Road
Port Levy Road
Lincoln Road
TAITAPU
TEDDINGTON

Christchurch is one of the cities of New Zealand that are having to prepare for the mounting volume of traffic on their streets. This book provides a logical and coherent account of the first full study of traffic in a New Zealand city. It describes the present pattern and intensity of urban land use, and analyses the movements of people and vehicles that are associated with the daily workings of the city. The reader is taken through the processes by which land use and traffic are projected twenty years ahead, and the volume ends with a discussion of problems arising from the growth of traffic in an expanding city of the New World.

Traffic in a New Zealand City is not intended solely for persons working professionally in the field of transport and urban development. The problems posed by the growth of traffic, especially in cities, are amongst the most controversial and baffling which face communities today. This book, though dealing with rather complex topics, is written and illustrated in terms that laymen can follow, because of the urgent need for wide public understanding of the nature and scale of the problems that are rapidly developing in New Zealand cities. World-wide concern with the central theme of this book makes *Traffic in a New Zealand City* of interest to citizens of many other countries.